# ANNALS

OF

# The Entomological Society of America

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ANNALS
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Volume XXV MARCH, 1932 No. 1

# HOROLOGION, A NEW GENUS OF CAVE BEETLES (Fam. Carabidae).

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## INTRODUCTION.

The following description deals with a unique genus of small, eyeless ground beetle, a single specimen of which was taken by the author from a tiny cave near Lewisburg, W. Va. Situated in the valley of the Greenbrier River, this cave is in richly cavernous country featuring numerous sink-holes, tunnel-like subterranean waterways and passages—caverns in early stages of formation. The author has visited 7 of the many caves known to occur within 20 miles of this spot, but in spite of diligent searches and extensive trapping here and elsewhere, no second representative of the genus has yet been brought to light. Since the habits of this beetle are not sufficiently well known to assure the collector of success in its capture, and because it is such an aberrant form, the author has taken the liberty of presenting it from the material at hand—a single, perfect male specimen.

Much more minute than the relatively large anophthalmids which ran rapidly over a piece of wood held in the author's hand, and differing vastly in behavior from them since it preferred to burrow for safety rather than run, this carabid was at once recognized as something very unusual. With some difficulty, it was dug from a crevice in the wood and captured.

The cave in which the find was made is on the property of Dr. Arbuckle, whose home is 3 miles north of Lewisburg, near Maxwelton, on State Route 24. Its opening, 500 yards east of the highway, is in a small sink-hole in a pasture; it leads abruptly downward to the first of the two rather small rooms.

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The upper is quite dry and dimly lighted from the entrance; the lower is wet and muddy, and quite dark. A narrow, descending, tortuous passage connects them. The subject of this paper was discovered in the lower level, on a small piece of wet, decaying wood, in a narrow space between the mud floor and an overhanging curtain of dripstone.

The author wishes to express his deep appreciation of helpful advice and material given him by H. S. Barber and L. L. Buchanan of the U. S. Dept. of Agriculture and by Dr. R. Jeannel of the Muséum National de France. To Dr. W. E. Caldwell of the Univ. of North Carolina he is indebted for suggestions relative to the nomenclature.

## Gen. **Horologion** nov. Valentine.

(Greek = hour glass.)

*General Description.*—Small, moderately elongate, highly convex; depigmentation rather less advanced than in the majority of anophthalmids; no trace of eyes; pubescence strongly developed, but the long tactile hairs and setae not as hypertrophied as in most cavernicole trechinids; microsculpture relatively rough; although there is evidence of spinescence, there is a decided lack of angulation where expected at the corners of pronotum and elytra; appendages quite short and the legs considerably stronger than in typical anophthalmids. (Pl. I, Figs. 1, 2.)

*Head.*—Sides not strongly convex; frontal grooves incomplete; 2 supraorbital setae on either side; anterior labral margin almost transverse; mentum articulate, its medial tooth simple, its paired sense organs situated centrally; anterior margin of ligula transverse and supplied with but 3 setae, the longest of which is medial and arises from a papilla slightly posterior to the margin; paraglossa rather short, spatulate, glabrous. (Pl. I, Fig. I; Pl. II, Figs. 6, 8.)

*Paired Buccal Appendages.*—Mandibles slender, bidentate[1], with a small cusp anterior to the retinaculum on the left side, and each bearing a single curved seta in its outer scrobe; maxillae with terminal segment of galea curved in conformity to digitus and closely appressed to same; terminal segment of maxillary palpi subcylindrical, nearly as long as subterminal segment, its apex obtuse; terminal segment of labial palpi similar, very slender and equal in length to that of the maxillary palpi.

*Antennae.*—Filiform, transition from subcylindrical to fusiform segments abrupt at 5th segment; segments 2, 3 and 4, subequal; two terminal segments slightly enlarged, last lanceolate. (Pl. I, Figs. 1, 4, 4a.)

*Pronotum.*—Strongly constricted behind; posterior angles and posterior setae wanting; anterior setae present; reflexed margins narrow, confined to the anterior half. (Pl. I, Fig. 1.)

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[1]R. Jeannel. Monographie des *Trechinae;* L'Abeille, 32, 3, pp. 285–293.

*Elytra.*—Eliptical, humeri much reduced; broadly emarginate, and with wide ventrally inflexed portions; normal striae 6 in number, feebly impressed; a rather pronounced sutural stria may represent the vestige of the 1st, while the 8th may possibly find its homologue in a short shallow stria external to the apical carina; striae, including the recurved apical groove, absent in the apical portion; carina short, situated well up on side of elytra, and followed beneath by an inflexed fold of the apical margin; setigerous papillae[2] as follows: 1 basal, 6 marginals (humeral set 4, apical set 2), no discals, 3 apicals, the latter well removed from the apex; "flying-hairs" 3 on either side, arising from the 2nd and 6th papillae of the marginal set, and from the posterior marginal papilla of the apical set. (Pl. I, Figs. 1, 2, 5.)

*Ventral Surface.*—Prothoracic coxal cavities open behind; metathoracic coxal cavities entirely enclosed by sterna; mesosternum firmly united with its episterna, the sutures being extremely vague; mesosternum with a medial, longitudinal groove to receive the pronounced intercoxal apophysis of the prosternum; metasternal episterna small.

*Legs.*—Mesothoracic legs particularly short, metathoracic legs relatively long, especially their femora and tibiae; subapical spine of front tibiae borne on the posterior face, near the margin of the comb; front tibiae with well developed apical comb on the posterior dorsal face; apex of front tibiae produced to form an elongate lobe bearing the large apical spine on the ventral face; 2nd, 3rd and 4th segments of front tarsi of male slightly and symmetrically dilated, not spinescent, the 3rd segment bearing a curved spine ventrally and the 1st and 2nd a ventral row of stalked adhesive organs. (Pl. I, Fig. 1; Pl. II, Fig. 9.)

*Male Genitalia.*—Genital ring elongate, triangular; copulatory organ broadly rectangular and relatively wide; penis in the form of a deep trough, open dorsally along its entire extent, not heavily chitinized except on its ventral surface, rather deeply arcuate and slightly bent to the left at its base; basal bulb absent, 2 prominent basal lobes taking its place; internal sac armed with a long, spiral, chitinized filament dorsally located, and a more ventral, elongate, less chitinized body associated with a series of minute parallel ridges; lateral lobes eliptical, the right slightly larger than the left, bearing many pore-like sense organs on the terminal third and a row of setae on the apical border. (Pl. II, Figs. 10, 11, 12, 13).

**Horologion speokoites** sp. nov.

(*speokoites:* Greek = lodges in a cave.)

With the characters of the genus and the following:

*General.*—Total length (distance from elytral apex to the further apex of the closed mandibles measured as a chord) 3.45 mm.; color: light reddish brown, labrum, maxillary and labial palpi and antennae pale yellow, the latter organ deepening to fuscus on its basal 5 segments,

[2]R. Jeannel. Monographie des *Trechinae;* L'Abeille, 32, 3, pp. 321–329.

legs and apex of elytra light yellowish brown; texture: roughly punctate, shining, clothed in coarse, sparse, decumbent pubescence. (Pl. I, Fig. 1.)

*Head.*—Rectangular, sides feebly arcuate, optic areas hardly extending beyond sides of occiput; length from anterior end of occiput to free margin of labrum .56 mm., width across optic areas .60 mm.; frontal grooves feebly impressed and incomplete; epicranium and genae roughly pitted, thinly clothed with long coarse pubescence; occiput glabrous, finely reticulate; labrum finely but distinctly reticulate, its anterior margin slightly extended medially. (Pl. 1, Fig. 1; Pl. II, Fig. 8.)

*Antennae.*—Length 1.92 mm.; segment 2 equal to 3 and one-tenth longer than 4; basal segment less pubescent than the others. (Pl. I, Figs. 4, 4a.)

*Pronotum.*—Strongly convex, subpyriform, longer than wide; sides evenly arcuate to about seven-tenths of their entire length, then proceed backward in straight converging lines which flow without interruption into the much rounded hind angles and evenly convex base; sparsely clothed, as head, with strong, decumbent hair, directed anteriorly over apical half and posteriorly over basal half; punctation of disc less pronounced than that of head; base strongly rugose; length, .72 mm.; width at widest point, .70 mm., at apex, .59 mm., at base, .41 mm. (Pl. I, Fig. 1.)

*Elytra.*—Twice as long as wide, narrow at humeri, tapering markedly at base; length, 2.04 mm.; width at widest point, 1.08 mm., at humeri, .90 mm.; margin narrowly reflexed, interrupted near the base by a conspicuous obtuse spur marking the forward projection of a longitudinal discal ridge; from this point posteriorly, the margin is thrown into a series of crenulations and serrations most accentuated from the humeri to a point approximately one-third the distance to the apices; near the humeri, small irregular teeth are located; vague undulations of the margin continue for two-thirds of the elytral length; at a distance from the apex of one-eighth the elytral length, a sudden angulation and elevation caused by an internal fold of the inflexed border marks the position of the short apical carina; from here to the produced and downwardly flattened apices, the margin is quite straight; the apices are acutely angular, slightly asymmetrical and separated; the striae, of which 7, possibly 8, are discernible posteriorly, are evinced by extremely shallow grooves or rows of fovea; the above mentioned, low discal ridges run over the basal third of the elytra in broad sigmoid curves roughly parallel to the suture, the area between them being somewhat flattened; on either side between the scutellum and this ridge, which becomes carinate near the marginal spur, there lies a distinct concavity; except for these depressions, which are densely and finely punctate, and the apices, which are shallowly and irregularly sculptured, the discs are coarsely and sparsely punctate, each puncture being the site of a strong decumbent hair; a large basal papilla is present at the base of the 1st and 2nd apparent striae, a little behind the end of the scutellum; the first 2 papillae of the marginal series occur close to the reflexed edge, the other 4 are situated on or near the 6th apparent

stria marking the internal boundary of the margin; the papillae of the discal apical set form a small triangle near the carina and remote from the apices. (Pl. I, Figs. 1, 2, 3, 3a, 5.)

*Scutellum.*—Elongate, acutely lanceolate; punctate at base.

*Ventral Surface.*—With the exception of the abdominal sternites, more sparsely hairy than above; the gula, occiput and tergal pieces glabrous or nearly so; gula and prothorax relatively smooth; abdominal sternites coarsely but sparsely punctate; tergites, except those of the prosternum, profusely and coarsely punctate, the mesosternal episterna being rugosely so. (Pl. I, Fig. 2.)

*Legs.*—Fore and mid coxae nearly glabrous, hind coxae hairy; mid and hind legs, from trochanter to tibia inclusive, more hairy and sculptured than fore legs; lengths of the principal segments of fore, mid and hind legs compared: femora, .66 mm., .72 mm., 1.08 mm.; tibiae, .66 mm., .78 mm., .90 mm.; tarsi, .03 mm., .04 mm., .05 mm.

*Male Genitalia.*—Genital ring .08 mm. in length, its base arched outward and its apex spatulate; penis .05 mm. in length (measured as a chord), flattened above, strongly arched below; apex blade-like; terminal setae of lateral lobes 6 in number. (Pl. II, Figs. 10, 11, 12, 13.)

*Type.*—Male; Arbuckle's cave, Maxwelton, W. Va.; July 12, 1931; col. Valentine.

*Relationships.*—The following lists of diagnostic characters are intended to bring out, as clearly as possible, the isolated position of *Horologion* gen. nov.

i. Characters combining to place *Horologion* as a near relative of the *Trechinae*, *Bembidiinae* and *Pogoninae:*

(1) Head bearing 2 supraorbital setae on either side.
(2) Antennae having no glabrous basal segments.
(3) Mandibles each with a single seta in the external scrobe.
(4) Prothoracic coxal cavities open behind; mesothoracic coxal cavities entirely enclosed by sterna.

ii. Characters[3] of *Horologion* tending toward the *Trechinae* and serving to distinguish both from the *Bembidiinae:*

(1) Frontal grooves distinct, separating large optic areas from the vertex.
(2) Terminal segment of maxillary palpi nearly as long as subterminal; subterminal segment glabrous.
(3) Terminal segment of galea short, less than one-half the length of the basal segment.
(4) Penis trough-like, 2 basal lobes taking the place of a basal bulb; lateral lobes armed with 6 marginal setae.

iii. Characters[3] diagnostic of the *Trechinae* but departing from *Horologion:*

(1) Margin of ligula with 2 large central setae and a series of 3 or 4 smaller ones on either side; paraglossa long, arciform and ciliated.

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[3]R. Jeannel. Monographie des *Trechinae;* L'Abeille, 32, 3, pp. 371-375.

(2) Marginal setigerous papillae of elytra 8; discal set 2.
(3) Front tarsi of male with the first segment at least, and usually 1, 2 or 3 of the following segments also, asymmetrically dilated; 4th segment in either sex with a forward-pointing process or a pair of such processes borne ventrally.

iv. Characters[3] of *Horologion* tending toward the *Bembidiinae* and serving to distinguish both from the *Trechinae:*

(1) Ligula bearing a large medial seta flanked by a small lateral seta on either side; paraglossa short, spatulate and glabrous.
(2) Subapical spur borne by the discal posterior face of the front tibiae.
(3) Base of penis bent laterally; basal bulb absent, basal lobes being well developed.

v. Characters diagnostic of the *Bembidiinae* but departing from *Horologion:*

(1) Terminal segment of maxillary palpi shorter than subterminal, the latter pubescent.
(2) Terminal segment of galea long, its length being greater than one-half that of the basal segment.
(3) Marginal setigerous papillae 8; discal set 2.
(4) Penis closed except at base and apex; setae borne by the lateral lobes less than 4 in number.

vi. Characters common to *Horologion* and *Patrobus* (*Pogoninae*):

(1) Terminal segment of labial palpi as long as that of maxillary palpi; subterminal segment of the latter glabrous.
(2) Position of subapical spur on the posterior discal face of front tibiae.
(3) Penis with basal lobes in place of a basal bulb.

vii. Characters diagnostic of *Patrobus* but departing from *Horologion:*

(1) Ligula with a median seta but no lateral setae.
(2) Galea of the bembidiinid type.
(3) Marginal setigerous papillae 9; discal set 2.
(4) Front tarsi with two rows of adhesive organs borne ventrally by the first and second segments.
(5) Penis closed except at base and apex; internal sac with basal armament.

viii. Aberrant characters of *Horologion:*

(1) Extreme constriction of posterior pronotum; reduction of pronotal margins and loss of posterior setae.
(2) Reduction of elytral striae to 6; complete loss of apical recurved stria.
(3) Marginal denticles and basal carina borne by elytra.
(4) Absence of discal setigerous papillae on elytra and reduction of the marginal series to 6.
(5) Conspicuous apical comb borne by front tibiae.
(6) Front tarsi of male having the second, third and fourth segments symmetrically expanded, and the first and second equipped with a single row of adhesive organs, ventrally located.

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[3]R. Jeannel. Monographie des *Trechinae;* L'Abeille, 32, 3, pp. 371–375.

DISCUSSION.

*Horologion* may be clearly traced to the *Carabidae harpalinae bisetosae* where it seems to occupy a primitive, intermediate position close to the *Trechinae*, the *Pogoninae* and the *Bembidiinae*. Of these 3 subfamilies, it corresponds closest, in general anatomical features and in habits, to the *Trechinae*. However, to admit it within this group would necessitate a drastic revision of the diagnostic trechine characters as outlined by Jeannel, a step which might too seriously disrupt the unity of the subfamily. Rather than erect a new tribe of *Trechinae* or a new subfamily for the reception of *Horologion*, it seems wiser to wait until more carabid types have been critically examined and more material of the genus has been collected.

The ligula, the fore tibia and tarsus, the elytral striae and setigerous papillae combine to throw the new form quite definitely clear of the *Trechinae*, while the maxilla and particularly the head-form serve to firmly reestablish the relationship. The ligula is reminiscent of certain bembidiinids, especially *Idacarabus* (tribe *Merizodini*), nor does it differ greatly from that of *Patrobus* (*Pogoninae*). The male copulatory organ is built on the same plan as that found in the tribe *Trechodini*[4] of the *Trechinae;* however, a trenchant difference separating *Horologion* from this group is the bidentate mandible possessed by the former, a character serving to associate it with the true cavernicole *Trechinae* (tribe *Trechini*)[4]. But these are forms in which the penis is tubular and has a basal bulb.

Resemblance to the platynoid genera *Anchonoderus* and *Atranus*, and also to the aberrant *Ega*, may be carried as far as similarity of general form, sculpture and hairiness, and a certain correspondence in penial equipment; however, the presence of a basal bulb in these carabids, and their mouth parts which differ fundamentally from those of *Horologion*, constitute sufficient evidence for the assumption that parallelism rather than near relationship is responsible for the likeness.

The discal position of the subapical spur borne by the front tibia does not serve to place the new form in any definite carabid group, but rather to assist in its removal from the *Trechinae*.

After critical work has been done on the rather miscellaneous genera which constitute the *Pogoninae*, the exact position of

[4]R. Jeannel. Monographie des *Trechinae;* L'Abeille, 32, 3, pp. 396–397.

*Horologion* will perhaps be revealed. In the meanwhile, it is interesting to speculate upon this form as representing a primitive connecting type, exhibiting a remarkable combination of generalized and specialized characters. In spite of having attained a high degree of spinescence, it has survived, apparently, by virtue of its cloistered life in caves.

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## EXPLANATION OF PLATES.

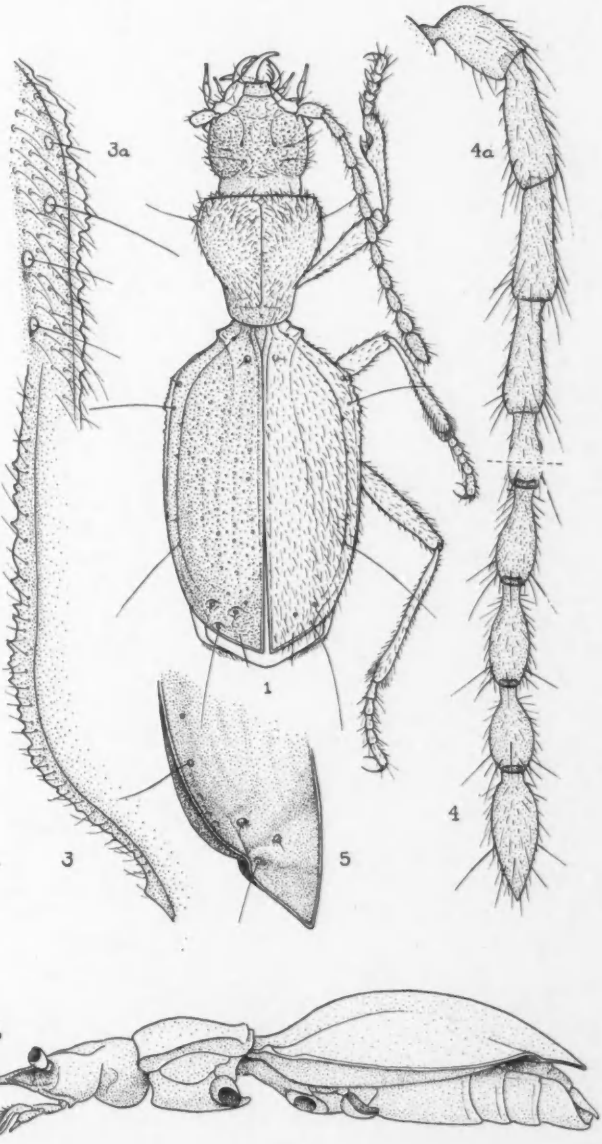
*Horologion speokoites* gen. sp. nov. Valentine. Type male.

### Plate I.

Fig. 1. Dorsal view; to exhibit the elytral sculpture and pubescence with clarity, the former has been omitted from the right elytron, the latter from the left.
Fig. 2. Diagram of left side, mandible extended.
Fig. 3. Humeral margin of left elytron, ventral view.
Fig. 3a. Humeral margin of right elytron, dorsal view.
Fig. 4. Apical segments of right antenna.
Fig. 4a. Basal segments of right antenna.
Fig. 5. Apex of right elytron, dorsolateral view.

### Plate II.

Fig. 6. Mentum, labium and labial palpi, ventral view.
Fig. 7. Left maxilla, ventral view.
Fig. 8. Mandibles and labrum, dorsal view.
Fig. 9. Apex of right front tibia and entire tarsus, anterior face.
Fig. 10. Copulatory organ, right face.
Fig. 11. Armament of internal sac seen through the right wall of penis.
Fig. 12. Copulatory organ, tergal view.
Fig. 13. Genital ring.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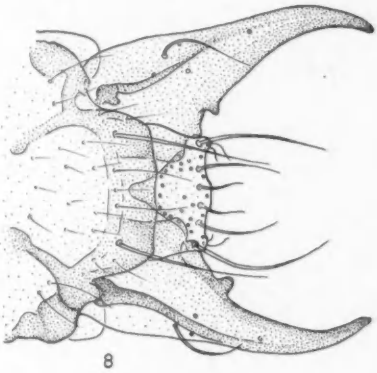

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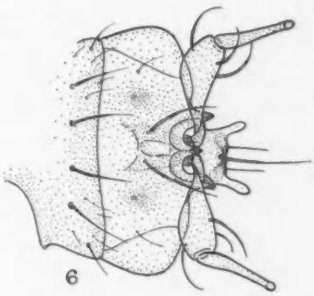

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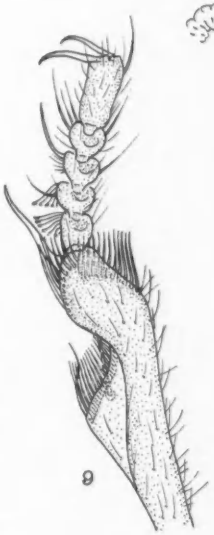

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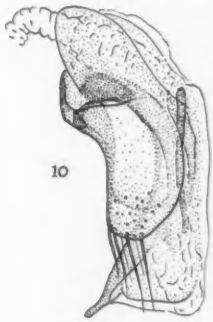

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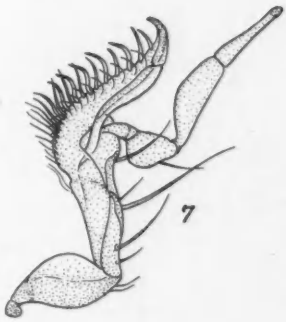

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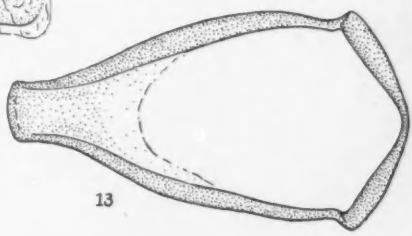

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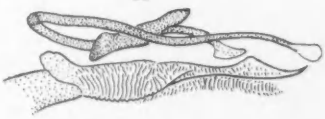

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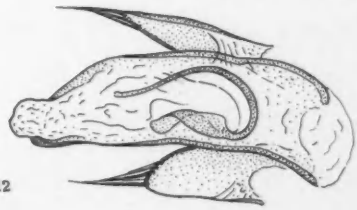

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# SOME PROBLEMS ENCOUNTERED IN THE ESTIMATION OF INSECT POPULATIONS BY THE SWEEPING METHOD.

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The accurate estimation of insect infestation in the field is a difficult problem especially when work is performed with insects which are quite active. Attempts have been made in recent years to determine relative populations of various types of insects upon many types of plants and crops. Certain of these populations are easily estimated since the insect is of such a torpid or inexcitable nature that it can easily be studied upon the plant without disturbing it. Certain types may become rather well attached to the plant tissues and such populations are very easily estimated. On the other hand, certain types of insects, such as leafhoppers, are very active and here real difficulties arise when attempts are made to estimate populations. In dealing with this latter type the movements of the investigator when approaching the plant or disturbing it in the least cause the insects to leave it readily. In order to capture active insects several investigators have resorted to the sweep net in an attempt to obtain a representative sample. In such cases a definite number of sweeps of a certain stroke is made in a given field or crop.

The writer has been engaged in comparative insect population studies upon certain truck and field crops for the past few years. He has also had the opportunity to associate with other field workers who are attempting to determine similar populations on a large scale. In view of the fact that many problems have been encountered due to the variables which enter into the method of sampling, the more obvious and important factors which cause variation in the numbers caught are being presented here with the idea that they will probably be of interest to other workers.

It is impossible to capture by the sweep method all or a definite proportion of the insects which occur in a given area. The proportion captured will vary greatly even if one person does the sweeping and the populations remain constant. The

capture depends largely upon their reaction to various stimuli and these stimuli will vary in predominance or complexity at different times or under different or changing conditions. Many physical factors are involved in this complex and as these are constantly changing, certain of them will intermittently dominate others and cause varied reactions.

Many of these factors may influence the rate of the reaction or the type of response and consequently determine the relative or variable numbers in the population samples.

Temperature is a very important factor since varying temperature affects metabolic rate and the rapidity of the "jump" reaction. In areas or under conditions of rather marked daily fluctuations in temperature the reactions of the insects at different periods of the day are rather variable, and the estimates of populations in specific fields vary in like manner if taken at periods during the day corresponding to these temperature changes.

Temperature is important in another very marked way. Under conditions of extreme temperature or marked fluctuations during short periods, the insect apparently changes its position on the plant in response to these changing physical conditions and may be found on the higher portions of the plant, near the surface of the ground, or even below the surface at times. Humidity may also be a factor in this reaction, but this orientation appears to be more closely correlated with temperature as it occurs during periods when there is great change in temperature and only slight change in humidity. In view of this changing condition or orientation upon the plant, sweeping must be performed at a different height at different times, within a given period, if the same or comparable population samples are to be secured. Under these conditions the uniform method used by the operator does not give comparative samples.

On the other hand, if sweepings are taken at different heights at the same time, the population samples will vary especially regarding the percentages of different species in view of the fact that different species are frequently distributed differently upon any given plant, especially herbaceous types. Height of sweeping correlated with physical factors is therefore very important regarding both the quantitative and qualitative population samples which are secured under any given complex of environmental factors.

It has been commonly observed in humid regions where there is a rich growth of herbaceous vegetation that many species of grassfeeding leafhoppers normally or frequently leave the shorter herbaceous layer of vegetation to remain upon the shrubs or taller plants during the night. This has been observed only under conditions of high humidity and is apparently a reaction to increased humidity. It is obviously an entirely different reaction from the orientation upon the food plant which occurs during the day.

Another physical factor of great importance in the estimation of populations is wind velocity. When a strong wind is blowing, certain species of hoppers may leave the plant and hiding among the clods of earth remain there during rather long continuous periods while the wind is blowing, or they may seek shelter among the thick clump of stalks or stems of the plant near the surface of the soil. In either case it is practically impossible to dislodge them and to secure populations of any size, although the plants may be heavily infested either a few hours before or afterwards.

If the wind is more gentle and the hoppers remain on the plants, the populations will vary according to whether the operator moves into the wind, with the wind, or across it when obtaining the sample.

The position of the sun may also play a part in the fluctuation of population samples. The shadow made by the operator may frequently cause the hoppers to jump before being disturbed by the sweep net.

The size and the condition of the plant are frequently very important factors. If the plants are very small it is difficult to secure representative samples of the populations which may be present by the sweep method, as the proximity of the ground interferes with both rapidity and direction of the stroke of the sweep as well as causes the accumulation of foreign materials in the net which frequently destroy or break these frail insects so that the population sample cannot be estimated. If the plants are especially large, it is not always an easy matter to sweep them so as to obtain a representative sample. Such factors as the thickness or density of the foliage, the pubescence of the leaves or stems, and similar conditions may greatly retard the sweep of the net; and the force of the stroke may soon be spent allowing the hoppers to escape before the net has

reached them. Or they may be temporarily protected beneath the dense foliage and escape capture.

Both the rapidity and length of the stroke in sweeping, especially when combined with varying temperature, may be factors in determining the comparative size of the population sample. The reaction of the specific insect or species is a very important factor in this respect. Frequently the back stroke following quickly the forward stroke is important and a more representative population sample is obtained by two such strokes over the same vegetation. When sweeping is performed rather rapidly while the investigator is walking through a field, the cross stroke frequently causes the insect to jump and the back stroke is responsible for its capture.

In other types of population studies as well as leafhopper samples, the problem of uniform infestation in the field is very important. Certain species of leafhoppers live upon wild host plants during the early season and migrate later to cultivated fields. Certain other species may hibernate under a specific condition outside the cultivated field and may migrate from either long or short distances. The rate of migration into the field and the consequent establishment is an important factor in insect population studies. The distance into the field from a particular point or area may determine the size of the population sample. It is extremely difficult under such conditions to obtain uniformity in a single field or a series of fields.

Certain farm practices or operations may also cause peculiar local conditions or changes in populations. For instance, the cutting of a field of alfalfa may cause enormous migrations of leafhoppers to adjoining fields or plots.

Migration may frequently be caused by varying degrees of age or succulence in plants. The hoppers will normally migrate to younger plantings for feeding or egg laying. Such migrations cause rather sudden and varying degrees of insect populations upon different fields or plantings.

It is almost impossible also in using the sweep method to gain any accurate information concerning the nymphal populations of leafhoppers. A considerable number of species like *Agallia sanguinolenta* Prov. and *Eutettix tenellus* Bak. can be secured, but species of *Empoasca* and related genera are very difficult to collect in this stage by sweeping.

In view of these and other changing factors, it is extremely difficult to determine or obtain information upon relative populations of these active insects because it is almost impossible to duplicate a given condition in the field and to secure a comparable representative sample. The difficulty of interpreting relative field conditions and the relative importance of each of these changing factors as well as the inability to evaluate each is probably the cause for our unsuccessful attempts to determine populations accurately by this method. A very rough inaccurate estimate is the best that can be hoped for by the sweep method for these active insects.

Upon trees or taller types of vegetation the difficulties encountered in the sweep method can be avoided and an excellent population sample obtained by using a quick acting gas-producing material like calcium cyanide dust. By placing a large canvas under the plant the entire population can be obtained and examined. It is extremely difficult, however, if not impossible to obtain populations in this manner from low plants, especially those of a herbaceous nature because the insects are disturbed when the investigator is adjusting the container in which to catch them. If on the other hand the plants are treated with gas without a receptacle for collecting the insects, these specimens cannot be secured later because of their small size and their consequent obscurity upon the ground.

The sweep method is undoubtedly of value in the securing of qualitative data and in determining the predominant and least prevalent species of leafhoppers in any population complex, but it is doubtful in view of the variables stated above if any accurate estimates can be made regarding relative populations by this method.

# A REVIEW OF SOME GENERA OF HESPERIINAE. (HESPERIIDAE, LEPIDOPTERA).

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A. W. Lindsey's paper in 1921 on the Hesperioidea of America north of Mexico (3) recorded in condensed form the results of the most inclusive study of these insects that had then been made, but left numerous relationships unsettled, especially among the commoner Hesperiinae. The six papers by Skinner and Williams in 1922–1924 (6), illustrating the genitalia of practically all North American species, went far towards solution of the remaining difficulties. Finally, in April, 1931, Lindsey, Bell and Williams published the latest and best comprehensive work (4), using the genitalia in combination with other taxonomic characters. But the obvious derivation of most of our genera from the rich neotropical fauna tends to weaken our native distinctions between small allied groups well represented southward. And even if necessity has largely justified our ignoring the tropical forms, there still appear to be more genera "recognized" than are easily definable.

The intention of this paper is to distinguish, by the characters of the genitalia, certain groups which are outstanding among the Hesperiinae (formerly called Pamphilinae) and to merge others that are closely related and have the least substantial differences. Although the work of a "lumper" in taxonomy may at times be open to practical criticism, it is clear that the Hesperiidae are no longer legitimate prey for the "splitter."

A word about the taxonomic value of the genitalia: the uncus (dorsal organ) offers occasional important characters, such as a pair of lateral hooks distinguishing the genus Choranthus. The valve is very useful in recognizing species and often genera, notably Euphyes, Problema and Hesperia. The aedoeagus or penis is elaborately armed in most of the species mentioned here, but through the great majority of the

Hesperiidae it is much simpler; consequently more valuable characters are borne by it in this group than in others. The illustrations are original except that of *arogos*, which is after Skinner and Williams, and are representative of various groups of species discussed.

As long as the name Pamphila was in common use for the typical genus of this subfamily, while Hesperia was employed, also incorrectly, for Pyrgus in the other main subfamily of the Hesperiidae, the former division was known as Pamphilinae and the latter as Hesperiinae. But the recent revision of names has changed them to Hesperiinae and Pyrginae respectively. The butterflies discussed in this paper, then, are the North American Hesperiinae that have vein $M_2$ of the fore wing distinctly curved and much nearer to $M_3$ at the base than to $M_1$, palpi oblique or appressed, with third joint moderate or small, and the cell of the fore wing less than two-thirds as long as the wing.

SYNOPSIS OF GENERA.

1. *Talides*. Valve with narrow posterior or dorsal cleft, the lower lobe more or less upturned and usually larger than the upper. Stigma present or absent. Mid-tibiae spined except in *logan* and *arogos*.
2. *Euphyes*. Valve dorsally cleft, lower lobe greatly expanded, not serrated but with two corners, edge concave. Stigma present, partially or wholly divided. Mid-tibiae spineless.
3. *Choranthus*. Valve dorsally cleft, lower lobe erect but moderate, neither angled nor serrated. Uncus with two erect lateral hooks and fused shield beneath. No stigma. Mid-tibiae spined.
4. *Problema*. Valve with two slender horizontal lobes, separated by almost the whole width of the valve. No stigma. Mid-tibiae spineless.
5. *Atalopedes*. Lobes of valve form two slender erect spines; stigma a single large blotch. Mid-tibiae spined.
6. *Hesperia*. Valve slender, armed with several erect spikes in two ranks, the inner more numerous. Stigma slender, divided. Mid-tibiae spined.

**Talides** Hubner, 1820.

Logotype *Talides athenion* Hubner.

The genitalia of the species here placed in Talides vary widely in details, but so gradually that to draw consistently any generic distinctions between them requires even more than have already been proposed from other characters. No Lepidopterist will consider this advisable.

**T. snowi** (Edwards). (Fig. 1.)

Snowi is apparently our only native species with a bilaterally symmetrical aedoeagus that could possibly be like the ancestral

type. The others are practically all distinctly asymmetrical. Here there are six chitinous processes arranged in three pairs, with a seventh terminal lobe. Nearest akin to *snowi* are the two Mexican species of Paratrytone, *rhexenor* and *polyclea* (3), which seem to be as close to *snowi* as they are to each other, and so should be included in Talides.

**T. verna** (Edwards). (Fig. 2.)

The genitalia of *verna* are fairly distinct among North American kinds, but two South American species examined, *pudorina* and *athenion*, show a similar valve, and there are doubtless others. But even without considering them, there would be no reason for a separate genus here.

**T. hobomok** (Harris). (Fig. 3.)

The illustration of *hobomok* typifies very closely *zabulon*, *taxiles* and *melane*, fairly well *viator*, *massasoit* and *sylvanoides*, while *agricola* and *morrisoni* merge with the following group. Several Old World species, including *sylvanus*, are characterized by the same conspicuous prong of the aedoeagus. The upturned lobe of the valve is perhaps the most constant trait of the group, for the aedoeagal processes are much smaller in *viator* and *massasoit* than in the rest.

**T. peckius** (Kirby). (Fig. 4.)

The northwestern *mardon* is the best intermediate form between *melane*, *agricola*, etc., and the allies of *peckius*, for it has a small rounded erect lower lobe of the valve instead of an acute slanting one, or a trident as in *sabuleti*. The latter is very close to *peckius*, however. Further apart stand *themistocles* and draco, with less formidable armature to the aedoeagus, but with valves much like the preceding. The Florida species *baracoa* differs in having an almost horizontal, sharply truncate lower lobe of the valve, which is nevertheless distinctly tridentate. The aedoeagus has two prongs extending caudad and downward, under a membranous canopy.

The species referred to Chaerephon have genitalia so similar to these that they should be placed very near them in Talides. There are two main prongs of the aedoeagus, with two or three smaller ones; the lower lobe of the valve is erect and toothed on the upper and outer edges. The three North American species are western or southwestern, and have allies in Mexico.

**T. logan** (Edwards). (Fig. 5.)

The long inferior lobe is similar to that of *aaroni* (New Jersey) and *howardi* (Florida), except that the latter have it pointed and also possess a more complicated aedoeagus. Skinner and Williams considered *howardi* a race of *aaroni*. The oblong chitinous flap just above the ventral edge of the valve in *logan* is represented in *aaroni* by a low point, but is practically absent in *howardi*. *Aaroni* also has two flat sub-rectangular plates lying within the aedoeagus, that are not found in *howardi*. Considering that the ranges of the two forms are separate, and that there is a distinct, if small, difference in size and wing-pattern, there seems little need of changing the category of species to that of races. *Logan* may not be as closely related to the other two as the genitalia suggest; it has evidently gone further in evolution, as is shown by the simplification of the aedoeagus and loss of the spines on the mid-tibiae. (See *arogos* and Euphyes below.)

**T. vibex** (Geyer). (Fig. 6.)

*Vibex* is tropical and straggles northward to Texas, where it has unnecessarily been called *stigma*. The widespread form in this country is *brettus*, and in the southwest its race *brettoides*. *Yehl* has genitalia almost exactly like those of *vibex*. The loose-lying, toothed or serrated bits of chitin are easily recognizable.

Opportunity is taken here to describe and figure a new species from Peru:

**Talides basistrigata** new species. (Figs. 7, 18–21.)

Expanse of males, 26–30 mm.; of female, 34 mm. Antennae of males, 4.5 mm.; of female, 5 mm. Collected at Lima, Peru, by Dr. W. T. M. Forbes; 1 male, 1 female, May 7, 1920; 5 males, May 16, 1920. Types in Cornell University collection.

The species is very close to *phylaeus*, but smaller, with antennae 1 mm. shorter. (Compare Figs 7 and 8. The photographs, Figs. 18–21, are about 2 mm. less than natural size.) The color above is light golden brown, like that of *phylaeus*, with dusky brown patches and a black stigma in the male. The light color of the female is much more extensive

than in *phylaeus*, but the male is indistinguishable from it on the upper side. Beneath a trifle paler than above. The longitudinal streak in the cell of the hind wing remains strong, even when the other markings of the wing are obscure, and is diagnostic of the species. It appears very faintly in a few specimens of *phylaeus*.

*Isonira* is the only other confusing form. It lacks the streak, has a zone of grayish outside the submarginal spots and has longer antennae than either *basistrigata* or *phylaeus*. *Isonira* was described in 1913 by Dyar (4) from southern Peru.

The genitalia of *basistrigata* are distinctly different from those of *phylaeus* (Fig. 8) and *isonira*, the valve possessing a toothed lower lobe, and the uncus a small basal projection on each side, barely if at all suggested in *phylaeus*, which may or may not be homologous with the lateral hook of Choranthus. The genitalia are of value here in showing the connection between *phylaeus* and the other species discussed. Those of *isonira* seem to be exactly like *phylaeus*, so that it is probably only a local race.

**T. otho egeremet** Scudder. (Fig. 9.)

This is the most widespread North American representative of Catia, founded in 1900 by Godman and Salvin solely on the basis of the peculiar stigma of the male. Lindsey (1921, repeated in 1931), in comparing Catia with Polites, states that "no fundamental or superficial similarity can be traced in the stigmata." In the five drawings of stigmata (Figs. 13–17), the first two are species of "Polites," the third and fourth are the subtropical and temperate forms, respectively, of "Catia" *otho*, and the fifth is a tropical species of "Catia," in which the long overlapping scales are shiny bronze. No comment on the similarity of the five is necessary. In justice to Dr. Lindsey it must be said that his remark was evidently founded on bleached wings, in which the difference in shape of the stigma patches is emphasized. The uncus and valve of the genitalia will be seen to have much in common with the preceding. The chief dissimilarity comes in the slender bifurcate aedoeagus.

**T. sonora utahensis** Skinner. (Fig. 10).

It is altogether likely, as Skinner and Williams point out, that *sonora* "may prove to be a western form of *mystic*."

Certainly the differences in genitalia are slight. The two round serrated plates are peculiar to these two forms and ***manataaqua***. They suggest an affinity to ***snowi*** through the two squared, roughly toothed lobes in the aedoeagus of the latter. But, among themselves, there could be no better example of the relationship of a few forms by common possession of a character that sharply distinguishes them from all others. If the "splitter" ever returns to the field of Hesperiidae, let him start by erecting a genus for these.

**T. arogos** Boisduval and Leconte. (Fig. 11.)

On account of the similarity of these genitalia to those of many species of tropical America, through which gradations to other types can be found, rather than because of a likeness to any particular North American form, it seems proper to include ***arogos*** in the extensive genus Talides. It is the type of Atrytone, and is included by Lindsey (3) and Skinner and Williams (6) in Atrytone with ***logan*** and the seven following species because of lacking mid-tibial spines.

**Euphyes** Scudder, 1872.

Orthotype *Hesperia metacomet* Harris (=*ruricola* Boisduval).

Figure 12, of the genitalia of ***vestris***, will be adequate for all the others of this genus. They have the lower lobe of the valve enormously expanded, concave on its upper margin, and the aedoeagus with no more than three or four simple little points, asymmetrically placed. The close similarity of the seven species to each other, but wide difference from any form which might be confused by other characters, seem basis enough for restoring the name of Euphyes, given by Scudder to the type species of the group. The included species are: ***vestris***, ***bimacula***, ***conspicua***, ***dion*** (all with the stigma "an interrupted dash"); ***arpa***, ***palatka*** and ***dukesi*** (with the stigma in "two separate spots").

**Choranthus** Scudder, 1872.

Orthotype *Hesperia radians* Lucas.

This genus includes three species, all tropical, ***vitellius***, ***radians*** and ***haitiensis***, the latter two in the Greater Antilles. They have a large erect hook on each side of the uncus, and a

shield underlying it, which has come from a fusion of the usually separate pieces. Otherwise there is no very distinctive character for the group. The valves of the three are not precisely alike, but all are intermediate between the form of ***snowi*** and that of ***arogos***. The genitalia of *Talides basistrigata* show that the lateral spines on the uncus of Choranthus are not altogether unique.

**Problema** Skinner and Williams, 1924.

Orthotype *Pamphila byssus* Edwards.

There is danger that Problema may become a too convenient receptacle for various problematic species, on the basis of superficial resemblance to ***byssus***. Already two have been deposited in it, namely, ***bulenta***, whose genitalia have not been examined, and ***morgani***, from South America, which, unlike the other two, has a stigma. To make this association of species particularly uncertain, the genitalia of ***byssus*** are strikingly different from those of any other North American skipper. Both lobes of the valve are horizontal and slender, but separated from each other by almost the whole width of the valve. The upper arm is the shorter. The present author can compare them only to certain species of Celaenorrhinus, but ***byssus*** is obviously more specialized. The butterfly itself looks like Padraona or Telicota, both characteristic oriental genera. There is one Padraona in Mexico, ***epictetus***, which has a quite different valve.

**Atalopedes** Scudder, 1872.

Orthotype *Hesperia huron* Edwards (Conspecific with *campestris* Boisduval).

*Campestris* has the two lobes of the valve curved upward as slender vertical spines; that of the upper lobe is shorter. The stigma of the male is a large imperfect oval, instead of a streak or pair of spots.

**Hesperia** Fabricius, 1793.

Logotype *Papilio comma* Linnaeus.

Most writers for over half a century have used the name of Pamphila (Fabricius, 1807) for the large genus typified by ***comma***, following Scudder's example. According to the modern rules of nomenclature, invalidating Scudder's opinion to the

contrary (5), *comma* was specified as the type of Hesperia by Dalman in 1816, by Swainson in 1820–21, and by Curtis in 1833; these take precedence over other specifications. The genitalia are remarkably uniform, with a simple aedoeagus and a rather narrow tapering valve armed with several erect spikes placed in two ranks. The inner rank is more extensive; it corresponds to the lower fold of the valve of *hobomok* and various others. There is apparently no distinction left in Hesperia between the two original lobes of the valve.

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## EXPLANATION OF PLATES.

### Plate I.

Male Genitalia.

Fig. 1. *Talides snowi.*
Fig. 2. *T. verna.*
Fig. 3. *T. hobomok.*
Fig. 4. *T. peckius.*
Fig. 5. *T. logan.*
Fig. 6. *T. vibex.*
Fig. 7. *T. basistrigata.*
Fig. 8. *T. phylaeus.*
Fig. 9. *T. otho egeremet.*
Fig. 10. *T. sonora utahensis.*
Fig. 11. *T. arogos.*
Fig. 12. *Euphyes vestris.*

### Plate II.

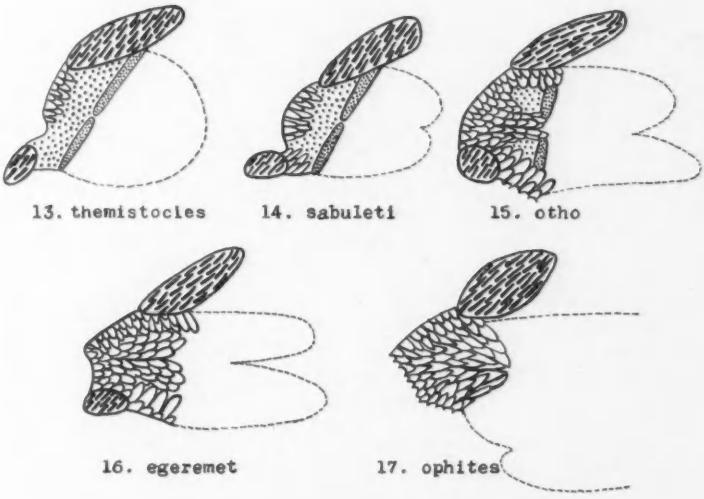
Male Stigmata.

Fig. 13. *Talides themistocles.*
Fig. 14. *T. sabuleti.*
Fig. 15. *T. otho.*
Fig. 16. *T. otho egeremet.*
Fig. 17. *T. ophites.*

*Talides basistrigata* n. sp.

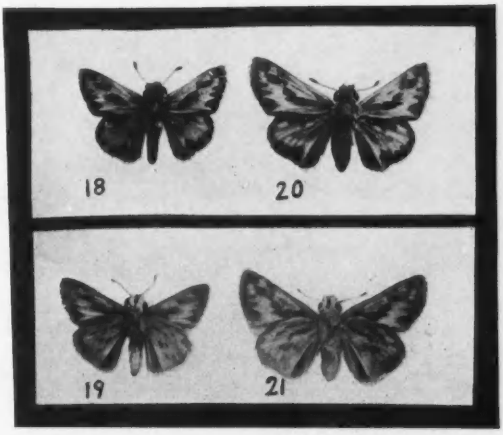
Fig. 18. Male, above.
Fig. 19. Male, below.
Fig. 20. Female, above.
Fig. 21. Female, below.

1. snowi
2. verna
3. hobomok
4. peckius
5. logan
6. vibex
7. basistrigata
8. phylaeus
9. otho egeremet
10. sonora utahensis
11. arogos
12. vestris



13. themistocles 14. sabuleti 15. otho

16. egeremet 17. ophites



# MORPHOLOGICAL STUDIES OF THE FEMALE GENITALIA OF CUBAN MOSQUITOES.[1],[2]

BERTRAM I. GERRY.

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Interest in the classification of mosquitoes, probably, received its initial stimulus from the investigations of Ross[3] (1897) on the relation between Anopheles and malaria, and those of Reed, Carroll, Agramonte and Lazear (1899), demonstrating the transmission of yellow fever by *Aedes aegypti* (Linn.).

Theobald[4] (1901–1910) attempted to classify the Culicidae by means of the scale vestiture, the shape and arrangement being utilized in generic differentiation. Since upon close scrutiny intergrades were found between the scale forms to which Theobald had given generic significance, his system proved worthless. The characters of the palpi also proved inadequate from a taxonomic standpoint. His classification

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[2]The writer is indebted to Dr. W. M. Wheeler and Professor C. T. Brues, of the Entomological Department of Harvard University; and particularly to Dr. J. C. Bequaert, who contributed all of the Cuban material, and in addition tendered many helpful suggestions. The writer also wishes to express his gratitude to Professor Nathan Banks, who generously offered an abundance of material for the comparative study; to Dr. F. M. Carpenter, for valued assistance and specimens of Mecoptera; to Dr. C. P. Alexander, who identified the Tipulidae and contributed several rare forms; and to Dr. G. C. Crampton, who extended many helpful criticisms concerning the morphological study.

[3]Ross found pigmented cells in Anopheles mosquitoes (1897); Grassi, Bignami, and Bastianelli (1898) published an account of the developmental stages of the malaria parasite in the stomach of *Anopheles claviger* Fabr.

[4]Theobald's "Monograph of the Culicidae" (1901–1910) consists of five large volumes.

based on the structural characters of the male genitalia failed because of the undue attention focused upon the appendages of the side-piece in an attempt to find generic differences, while the less conspicuous characters of the basal parts, necessary for specific distinction, were ignored.

In 1906 Dyar and Knab published keys to the larvae of the Culicinae of North and Central America in which the authors utilized such structural characters as length of air tube, condition of the mouth brushes, shape of the head and characters of the antennae to separate the genera; while less conspicuous characters such as: hair tufts, shape of the anal plate, shape and length of the gills, and characters of the pecten served in the separation of the species. This system not only facilitated the accurate identification of the larvae but at the same time tended to arrange the species on the basis of their phylogenetic relationships. Later, between 1912 and 1917, Howard, Dyar, and Knab classified the adult males on the basis of morphological structers of the genitalia; the phylogenetic sequence here being, in general, parallel to that shown by the classification of the larvae.

Unfortunately, only in material which has been bred out (and breeding out is a method not always convenient to apply) can one be sure of the relationship between larva and adult. On the other hand, the males are not blood feeders, and are therefore not attracted to man. Since field collections usually include neither the larvae nor the males, one must resort to the present keys for adult females which are adequate for generic determinations primarily because the genera are separated on certain morphological distinctions. Obstacles, however, promptly present themselves when one attempts to make specific determinations since the available keys for the identification of species are based primarily on scale coloration.

The limitations of the color pattern, as a means of identification, is well illustrated in Dyar's "The Mosquitoes of the Americas" (1928), where as many as eleven species of the genus Culex have been grouped together, the systematists having found insufficient differences in scale coloration to allow for separation.

Moreover, recent observations by Root (1926), on the *albimanus-tarsimaculatus* group, have demonstrated that the markings of the last tarsal segment differ in specimens of the

same species taken in different geographical regions, and also in specimens of the same species taken in the same locality at different seasons of the year. Davis (1928) suggested that a correlation probably existed between temperature and color extension. The observations made by Leeson (1930) on the variations in wing ornamentation of *Anopheles funestus*[5] Giles, favor the latter suggestion. Leeson demonstrated that the variations in wing markings are not solely related to sex or habitat, but that pale forms are more prevalent in the wet season, and dark forms in the dry season.

Many entomologists have long been convinced of the greater value of the more stable morphological characters as a means of classification. Muir (1928) writes as follows, "the taxonomic divisions are founded upon morphological characters, but the chief ones represent functional differences although described in terms of morphology. As we descend to the lesser divisions, the function is less apparent, and morphology appears as the chief criterion." He suggests that if the idea of function were carried into the lesser divisions it would be greatly to the advantage of taxonomy. He believes that the genitalia of insects are as vital to the race as the mouth-parts are to the individual; that they are not stabilized, but on the contrary respond to all changes of form, habits, and habitats of the individual, and, because of this response show decided differences of detail.

The results obtained from the classification of male Culicidae on the basis of morphological characters noted in the genitalia bear out Muir's view. This system tended toward an arrangement of the species according to their phylogenetic relationships and in addition proved more trustworthy as a means of identification than the superficial characters, namely, scale shape as used by Theobald and scale coloration as used by Dyar in his classification of adults.

The three principal objections to the use of genitalia characters as a basis for classification are; first, that the specimen must be somewhat mutilated; second, that the genitalia require preparation and mounting before a detailed examination may be made; and third, that the system is of little use in field identification. These objections are, however, of minor impor-

[5]An important vector of malaria in Africa.

tance where a correct determination is at stake, and where presumably the part removed is always accessible if permanently mounted and adequately labeled. Nor do these objections seem great when it is realized that the use of the genitalia eliminates the discouraging attempts (often futile) to identify by the keys used thus far, the beaten and half bare specimens which are frequently the only ones available.

## ILLUSTRATIONS.

The illustrations are simple outline drawings which represent only the principal morphological structures, many of the minor details being purposely omitted in order to enhance the identification of diagnostic characters. However, where setae are significant and of probable potential value in differential diagnosis, they have been included in the illustrations. The views included are not strictly dorsal and ventral, but represent certain aspects arrived at by a slight rotation of the genitalia upon the transverse axis. This rotation is sufficient to bring into a single plane, all of the more important diagnostic structures and setae groups. The lateral views, likewise, are not strictly lateral, but represent a comprehensive aspect produced by a slight rotation of the genitalia upon the longitudinal axis. Furthermore, the drawings for each individual species included, are supplemented by a written description of the same.

## METHOD OF PREPARATION.

The genitalia was first removed from the adult female by the use of a fine pair of scissors, relaxation being omitted in most cases. Extreme care is necessary in removing the terminal segments when the specimen is dry, for undue roughness will cause the abdomen to snap at the junction of the latter part and the thorax, and result in the loss of the entire abdomen. With care, one may remove the last three segments and still leave the anterior abdominal segments intact.

After the terminal segments have been removed, they should be placed in a 10 per cent aqueous solution of caustic potash. The period of time necessary for maceration depends upon three factors: (1) the strength of the solution used, variations from the original concentration being unavoidable because of the constant evaporation of water from the solution; (2) the size and the amount of sclerotization of the genital structures; and (3) the temperature at which the maceration occurs. If the specimen be placed in a boiling potash solution, the time element may be greatly reduced, that is to say, to a few minutes for the average sized genitalia. This method I believe to be hazardous when applied to the more delicate forms. If time permits, the better method for preparation of the more delicate genitalia is to place the potash solution containing the specimen upon a warm surface, and by periodic examinations ascertain the amount of reduction necessary for transparency, without, at the same time, rendering the structures colorless. A small

amount of chitin must remain in the finest structures in order that they may be visible under the microscope after the permanent mount is completed. Two to three hours on the warm surface seems to be the limit for the average sized genitalia of Culex and Aedes. The larger and more heavily sclerotized structures of the genera Mansonia, Psorophora, and Deinocerites require a somewhat longer period for preparation, while the more delicate genitalia of the genera Uranotaenia, Wyeomyia, and Anopheles require a slightly shorter period.

When the specimen has been sufficiently softened, it should be immersed for about five minutes in distilled water in order to remove all potash. At this time all loose organic matter may be pressed from the sclerotized cast. During the above operation the ninth and tenth segments should be extended. In Aedes and Psorophora these segments are naturally found withdrawn within the eighth segment. There is a rather extensive, infolded, delicate, intersegmental membrane between the eighth and ninth segments which allows for the extension of these parts. In Psorophora, the eighth segment is also membranous; the eighth, ninth, and tenth segments being withdrawn within the seventh.

These terminal segments may be extended at this time by holding the last typical segment of the abdomen firmly in place by means of a fine insect pin held in the left hand, while with the same type of pin in the right hand, one may press out those previously concealed. In many cases the pressure exerted upon the sclerotized cast during the removal of macerated tissue will be sufficient to flare out the intersegmental membranes thereby giving the desired extension of the posterior segments. All manipulations should be made while the specimen is immersed in distilled water as the membranes become quite brittle upon subjection to alcohol. After the removal of all caustic and organic matter, the terminalia should be passed through 70 per cent, 95 per cent, and 100 per cent alcohol. The specimen is then transferred to xylol, after which it may be mounted in balsam upon a glass slide, the period of immersion in each alcohol bath being not less than three minutes.

## MOUNTING.

In mounting, it is essential that fine pieces of glass wire be used to support the cover slip, otherwise the weight of the slip will tend to flatten out the structures and result in distortion. Following the disposition of the fine glass rods upon the slide, balsam is added to the preparation and the specimen transferred with spatula or forceps from the dish of xylol to the drop of balsam on the slide. It is usually necessary to check the location of the specimen before placing the cover slip, since convectional currents often carry the specimen away from the center of the field. Mounting may be accomplished without the aid of a binocular, but I found it convenient to carry out the final operation on the binocular stage; it is then a relatively easy matter to keep constant check upon the position of the specimen.

With material mounted in the above manner, it is possible, several months after the slide has been completed, to acquire varying views by

gently pressing upon the surface of the cover slip with a fine pointed instrument. When slides are more than one year old, a slight pressure exerted at the edge of the cover slip may cause the slip to move sufficiently to give the desired rotation to the cast. In most cases, remounting may be accomplished in a few minutes. If remounting is necessary, the cover slip is first removed from the old slide and a drop of xylol applied to the thickened balsam. The rigid cast may then be lifted out and the transfer accomplished with a fine pointed instrument. The natural rigidity of the cast will usually preserve its shape and prevent the occurrence of any distortion during the transfer.

## DESCRIPTIONS OF THE FEMALE GENITALIA.

### Subgenus **Nyssorhynchus** Blanchard.

Genus Anopheles Meigen. Syst. Beschr. Bek. Eur. Zweifl. Ins. 1: 10, 1818.
Genotype—*Anopheles maculipennis* Meigen. Syst. Beschr. Bek. Eur. Zweifl. Ins. 1: 10, 1818.
Subgenus Nyssorhynchus Blanchard. C. R. Soc. Biol. Paris, 23, 795, 1902.
Genotype—*Anopheles albimanus* Wiedemann. C. R. Soc. Biol. Paris, 23: 795, 1902.

#### **Anopheles albimanus** Wiedemann.

(Female Hypopygium, Plate II, Figs. 1 and 2.)

*Anopheles albimanus* Wiedemann. Dipt. Exot., 10, 1821.

Cerci cylindrical, apices rounded, outer margins convex, inner margins slightly convex, their notches on level with crest of anal segment, bases severely constricted. Postgenital plate triangular, one-fourth the length of cerci, apex obtuse, base separated from ninth sternite by wide intervening membranous area, apex surmounted by a single pair of long coarse setae. Cowl present, margins indefinite. Ninth sternite narrow, lightly sclerotized, somewhat constricted medially, widening on either side just lateral to median constriction, then gradually tapering to its junctions with bases of atrial plates and sigma. Atrial plates large, triangular, bases intimately associated with lateral extremities of ninth sternite, apices projecting medially. Sigma flat, membranous, ribbon-like, uniform in width, except anteriorly where the wide apron-like portion is fused with insula plate which supports a large group of fine setae. Ninth tergite narrow, bar-like dorsally, lateral wider areas forming loose articulations with extremities of ninth sternite. Tenth tergite uniform in width, membranous dorsally, the sclerotized lateral extremities extending ventrally. Anal segment membranous, domed, well expanded.

### Subgenus **Anopheles** Meigen.

Genus Anopheles Meigen. Syst. Beschr. Bek. Eur. Zweifl. Ins. 1: 10, 1818.
Genotype—*Anopheles maculipennis* Meigen. Syst. Beschr. Bek. Eur. Zweifl. Ins. 1: 10, 1818.
Subgenus Anopheles Meigen. Syst. Beschr. Bek. Eur. Zweifl. Ins. 1, 10, 1818.
Genotype—*Anopheles maculipennis* Meigen. Syst. Beschr. Bek. Eur. Zweifl. Ins. 1, 10, 1818.

**Anopheles vestitipennis** Dyar and Knab.

(Female Hypopygium, Plate II, Figs. 3 and 4.)

*Anopheles vestitipennis* Dyar and Knab. Proc. Biol. Soc. Wash., 19: 136, 1906.

Cerci cylindrical, apices rounded, outer margins convex; inner margins convex distally, expanded basally to form inner lobes, base constricted. Postgenital plate triangular, one-fourth the length of cerci, base separated from ninth sternite by narrow intervening membranous area, apex surmounted by single pair of long coarse setae. Cowl present, margins indefinite. Ninth sternite narrow, ribbon-like, lightly sclerotized, continuous laterally with sigma. Atrial plates large, triangular, bases not definitely joined to lateral extremities of ninth sternite, apices projecting medially. Sigma flat, narrow, membranous, ribbon-like, extending anteriorly and continuous with lateral extremities of narrow, bar-like atrial plate. Ninth tergite irregular in outline, the tapering lateral extremities extending ventrally on either side to form loose articulations with lateral extremities of ninth sternite. Tenth tergite uniform in width, membranous dorsally, sclerotized lateral extremities extending somewhat ventrally. Anal segment domed, aperture at apex lightly sclerotized forming a conspicuous crater.

## Subgenus **Phyllozomyia** Dyar.

Genus Wyeomyia Theobald. Mon. Culic., 11: 267, 1901.
Genotype—*Wyeomyia grayii* Theobald. Mon. Culic., 11: 269, 1901.
Subgenus Phyllozomyia Dyar. Ins. Ins. Mens., 12: 112, 1924.
Genotype—*Wyeomyia smithii* (Coquillett) Can. Ent., xxxiii, 260, 1901.

**Wyeomyia vanduzeii** Dyar and Knab.

(Female Hypopygium, Plate II, Figs. 5 and 6.)

*Wyeomyia vanduzeei* Dyar and Knab. Proc. Biol. Soc. Wash., 19: 138, 1906.

Cerci short, compressed, truncate, of nearly equal width throughout; distal half of outer margins slightly convex, basal half straight, inner margins convex, bases broad. Postgenital plate one-third longer than cerci, truncate at apex, restricted basally, forming an inverted triangle, distal third supporting numerous short spine-like setae irregularly arranged. Cowl indefinite, ninth sternite narrow, transverse portion slightly constricted medially, somewhat expanded at shoulders; lateral arms projecting anterodorsally, continuous with membranous sigma which doubles back ventrally and gradually increases in width to form apron-like portion which indicates position of insula plate. Sigma clothed medially with numerous fine setae. Ninth tergite with both anterior and posterior margins indented medially, lateral posterior margin straight, anterior margin convex, extremities extending somewhat ventrally, a pair of fine setae on either side laterad of median concavity of posterior border. Tenth tergite forming triangular sclerotized plates at bases of cerci. Anal segment membranous, concave, continuous ventrally with ninth sternite and laterally with extremities of ninth tergite.

## Genus **Uranotaenia** Lynch Arribalzaga.

Genus Uranotaenia Lynch Arribalzaga. Rev. Mus. de la Plata, 1: 375, 1891.
Genotype—*Uranotaenia pulcherrima* Lynch Arribalzaga. Rev. Mus. de la Plata, 2, 165, 1891.

### **Uranotaenia sappharina** (Osten-Sacken).

(Female Hypopygium, Plate III, Figs. 7 and 8.)

*Uranotaenia sappharina* (Osten Sacken). Trans. Am. Ent. Soc., 2: 47, 1868.

Cerci short, compressed, broad at base, inner margins straight; outer margins bellowed at base, convex beyond, forming a somewhat acute angle at the apex with the inner margin. Postgenital plate bilobed at apex, gradually widening basally and fusing with narrow sclerotized cowl, supporting two groups of four long apical setae; below these, two groups of five short spine-like subapical setae regularly arranged. Ninth sternite divided into narrow transverse and lateral sections, median transverse section dumb-bell shaped, its lateral extremities loosely articulated with median extremities of narrow lateral sections. Sigma large, well sclerotized, hood-like. Lateral extremities of cowl, ninth sternite, and sigma combined to form a common base on either side. Insula plate fused to anterior margin of hood and supporting a group of five fine setae. Ninth tergite narrow, regular in outline, extending ventrally on either side and forming a loose articulation with common base of cowl, ninth sternite, and sigma. Anal segment concave, obscured by bases of cerci, its lateral extensions continuous ventrally with the lateral portions of cowl and dorso-laterally with extremities of ninth tergite.

## Subgenus **Ochlerotatus** Theobald.

Genus Aedes Meigen. Syst. Beschr. Bek. Eur. Zweifl. 1, 13, 1818.
Genotype—*Aedes cinereus* Meigen. Syst. Beschr. Bek. Eur. Zweifl. 1, 13, 1818.
Subgenus Ochlerotatus Lynch Arribalzaga. Rev. Mus. de la Plata, 1: 374, 1891.
Genotype—*Aedes confirmatus* (Lynch Arribalzaga). Rev. Mus. de la Plata, 2, 146, 1891.

### **Aedes tortilis** (Theobald).

(Female Hypopygium, Plate III, Figs. 13 and 14.)

*Aedes tortilis* (Theobald) Entom., 26, 281, 1903.

Cerci long, compressed, leaf-like. Postgenital plate one-half the length of cerci, posterior free portion conspicuously expanded and bilobed, one and one-half times the average width of basal half, decided constriction half the distance from base to apex, lateral margins converging to form a narrow base; supporting two groups of three apical setae, below these, two groups of three short spine-like subapical setae alined obliquely. Cowl, fused to postgenital plate at the constriction, bellowed laterally and fusing with the lateral margins of the ninth tergite. Ninth sternite narrow, the transverse bar-like portion uniform in width, lateral shoulders slightly dilated, lateral arms twice the width of the transverse portion. Sigma uniformly narrow, projecting antero-

ventrally and continuous on either side with the narrow bar-like insula plate which supports two pairs of fine setae. Ninth tergite broad, anterior and posterior margins decidedly bilobed, each lobe of the posterior margin crowned by a group of six fine setae. Anal segment membranous and domed, continuous ventrally with the basal half of the postgenital plate and ninth sternite, and dorso-laterally with the ninth tergite.

### Subgenus **Taeniorhynchus** Lynch Arribalzaga.

Genus Aedes Meigen. Syst. Beschr. Bek. Eur. Zweifl. 1, 13, 1818.
Genotype—*Aedes cinereus* Meigen. Syst. Beschr. Bek. Eur. Zweifl. 1, 13, 1818.
Subgenus Taeniorhynchus Lynch Arribalzaga. Rev. Mus. de la Plata, 1, 374, 2, 143, 1891.
Genotype—*Aedes taeniorhynchus* (Wiedemann). Dipt. Exot., 43, 1821.

### **Aedes sollicitans** (Walker).

(Female Hypopygium, Plate III, Figs. 9 and 10.)

*Aedes sollicitans* (Walker). Ins. Saund., 427, 1856.

Cerci long, compressed, leaf-like. Postgenital plate one-half the length of cerci, emarginate, slightly expanded posteriorly, a noticeable constriction two-thirds the distance from base to posterior extremity; supporting two pairs of long apical setae, below these, two lateral groups of four or five short spine-like subapical setae, three of which are usually in file. Cowl narrow at line of fusion with postgenital plate, gradually expanding and fused laterally with posterior half of lateral margin of ninth tergite. Ninth sternite narrow, of equal width throughout, except lateral shoulders which are slightly dilated. Sigma narrow, width uniform, approximately equal to that of ninth sternite, continuous anteroventrally on either side with narrow bar-like insula plate which supports two pairs of fine setae. Ninth tergite broad, apex of each lateral plate crowned by a group of seven fine setae, six of which usually form a double row of three pairs. Anal segment membranous and domed, continuous ventrally with the base of the postgenital plate and ninth sternite, and dorsolaterally with ninth tergite.

### Subgenus **Taeniorhynchus** Lynch Arribalzaga.

Genus Aedes Meigen. Syst. Beschr. Bek. Eur. Zweifl. 1, 13, 1818.
Genotype—*Aedes cinereus* Meigen. Syst. Beschr. Bek. Eur. Zweifl. 1, 13, 1818.
Subgenus Taeniorhynchus Lynch Arribalzaga. Rev. Mus. de la Plata, 1, 374, 2, 143, 1891.
Genotype—*Aedes taeniorhynchus* (Wiedemann). Dipt. Exot., 43, 1821.

### **Aedes taeniorhynchus** (Wiedemann).

(Female Hypopygium, Plate III, Figs. 11 and 12.)

*Aedes taeniorhynchus* (Wiedemann). Dipt. Exot., 43, 1821.

Cerci long, compressed, leaf-like. Posterior plate one-half the length of cerci, emarginate apically, middle third gently narrowed, the lateral

margins diverging toward both base and apex and forming rather sharp angles with the posterior margin; apex one and one-half times the width of the base and supporting two groups of three long apical setae; below these, two groups of two short spine-like subapical setae. Cowl narrowly fused to the postgenital plate along a line located two-thirds the distance from the base to the apex; bellowed, and gradually expanding laterally to fuse with the posterior half of lateral margins of ninth tergite. Ninth sternite narrow, of approximately equal width throughout, except lateral shoulders which are slightly dilated. Sigma narrow, of uniform width, projecting anteroventrally and continuous on either side with the insula plate which supports two pairs of fine setae. Ninth tergite broad, nearly severed medially by a deep V-shaped indentation of posterior margin and inverted U-shaped indentation of anterior margin. Anal segment membranous and domed, continuous ventrally with ninth sternite, and basal two-thirds of postgenital plate, and dorso-laterally with ninth tergite.

## Subgenus **Howardina** Theobald.

Genus Aedes Meigen. Syst. Beschr. Bek. Eur. Zweifl. Ins. 1: 13, 1818.
Genotype—*Aedes cinereus* Meigen. Syst. Beschr. Bek. Eur. Zweifl. Ins. 1: 13, 1818.
Subgenus Howardina Theobald. Mon. Culic., 3: 287, 1903.
Genotype—*Aedes walkeri* (Theobald). Mon. Culic., 1: 424, 1901.

### **Aedes albonotatus** (Coquillett).

(Female Hypopygium, Plate III, Figs. 17 and 18.)

*Aedes albonotatus* (Coquillett). Proc. Ent. Soc. Wash., 7, 183, 1906, (gymnometopa).

Cerci long, compressed, leaf-like. Postgenital plate two-thirds the length of cerci, lateral margins regular, diverging slightly to form a wide base; apex ovate, supporting two groups of long apical setae, subapical setae numerous. Cowl absent. Ninth sternite broad, extending anterodorsally to form loose articulations with lateral margins of ninth tergite; posterior margin straight, anterior margin excavated medially, the indentation partially closed anteriorly by two spine-like processes produced medially from inner margins of the lateral arms. Sigma uniformly narrow, extending transversely from extremities of lateral arms of ninth sternite and continuous with the median insula plate which supports two groups of three setae each. Ninth tergite narrow, anterior and posterior margins deeply indented, dividing sclerite into two lateral plates joined centrally by a broad transverse cross-bar; posterior lobes of lateral plates crowned by a group of three fine setae. Anal segment membranous and domed, continuous ventrally with ninth sternite and basal third of postgenital plate, and dorsally with ninth tergite.

## Subgenus **Stegomyia** Theobald.

Genus Aedes Meigen. Syst. Beschr. Bek. Eur. Zweifl. Ins. 1: 13, 1818.
Genotype—*Aedes cinereus* Meigen. Syst. Beschr. Bek. Eur. Zweifl. Ins. 1: 13, 1818.
Subgenus Stegomyia Theobald. Mon. Culic., 1: 98, 283, 1901.
Genotype—*Culex fasciatus* Fabricius. Syst. Antliat., 36, 1805, [=*Aedes aegypti* (Linnaeus)].

### **Aedes aegypti** (Linnaeus).

(Female Hypopygium, Plate III, Figs. 15 and 16.)

*Aedes aegypti* (Linnaeus). Hass. Pal. Reise., 470, 1762.

Cerci short, stout, compressed, leaf-like, inner margins straight, outer margins strongly convexed. Postgenital plate two-thirds the length of cerci, of approximately equal width throughout, a sharp constriction half the distance from base to emarginate apex; two groups of four apical setae, below these, numerous short spine-like subapical setae irregularly arranged. Cowl indefinite. Ninth sternite wide, bowed; lateral shoulders indefinite but represented by dilation at middle of each lateral portion of the bow, lateral extremities somewhat expanded. Sigma uniformly narrow, supporting the median apron-like insula plate which is profusely clothed with fine setae. Ninth tergite U-shaped, lateral arms tapering slightly towards apices, each crowned with a group of four fine setae. Anal segment membranous and domed, continuous ventrally with ninth sternite and basal half of postgenital plate, and dorsolaterally with ninth tergite.

## Subgenus **Grabhamia** Theobald.

Genus Psorophora Robineau-Desvoidy. Mem. Soc. Nat. Hist., Paris, 3: 412, 1827.
Genotype—*Psorophora ciliata* (Fabricius). Ent. Syst., 4: 401, 1794.
Subgenus Grabhamia Theobald. Mon. Culic., 3: 243, 1903.
Genotype—*Psorophora jamaicensis* (Theobald). Mon. Culic., 1: 345, 1901.

### **Psorophora columbiae** (Dyar and Knab).

(Female Hypopygium, Plate IV, Figs. 19 and 20.)

*Psorophora columbiae* (Dyar and Knab). Proc. Biol. Soc. Wash., 19: 135, 1906, (Janthinosoma).

Cerci long, stout, compressed, leaf-like, inner margins straight, outer margins convex, wide basally, and somewhat overlapped by posterior lobes of ninth tergite. Postgenital plate one-third the length of cerci, divided by a transverse fold into a reduced distal third and greatly expanded basal two-thirds; apex bilobed, each lobe surmounted by a single pair of long stout setae, subapical setae absent. Cowl indefinite. Ninth sternite wide, transverse portion irregular in outline, anterior border notched medially, shoulders greatly dilated; lateral arms of uniform width, small ear-like processes of inner margins (just below shoulders) bent laterally, appearing to rest on lateral arms. Sigma uniformly narrow, extending anteroventrally and continuous with the narrow median insula plate which supports two pairs of fine setae. Ninth tergite elongate, narrowly forked anteriorly; posterior margin

bilobed, and overlapping the bases of the cerci. Anal segment reduced to a membranous strip continuous ventrally with apex of postgenital plate and dorsally with bases of the cerci.

### Subgenus **Janthinosoma** Lynch Arribalzaga.

Genus Psorophora Robineau-Desvoidy. Mem. Soc. Nat. Hist., Paris, 3: 412, 1827.
Genotype—*Psorophora ciliata* (Fabricius). Ent. Syst., 4: 401, 1794.
Subgenus Janthinosoma Lynch Arribalzaga. Rev. Mus. de la Plata, 1: 374; 2: 152, 1891.
Genotype—*Psorophora discrucians* (Walker). Ins. Saund., 430, 1856.

#### **Psorophora ferox** (Humboldt).

(Female Hypopygium, Plate IV, Figs. 21 and 22.)

*Psorophora ferox* (Humboldt). Voy. Reg. Equin., 7: 119, 1820.

Cerci long, stout, compressed, leaf-like, inner margins straight, outer margins convex; wide basally and somewhat overlapped by posterior portion of ninth tergite. Postgenital plate narrow, one-third the length of cerci, gently constricted at middle, wide basally; apex bilobed, each lobe surmounted by a single pair of long stout setae, subapical setae absent. Cowl indefinite. Ninth sternite narrow, transverse portion bar-like, regular in outline, shoulders not definitely dilated; lateral arms narrow, continuous with uniformly narrow sigma. Insula plate continuous laterally with sigma, and supporting two pairs of fine setae. Ninth tergite elongate anteriorly and broadly forked, posterior margin bilobed, and overlapping the bases of the cerci. Anal segment reduced to a membranous strip, continuous ventrally with apex of postgenital plate and dorsally with bases of cerci.

### Subgenus **Mansonia** Blanchard.

Genus Mansonia Blanchard. C. R. Soc. de Biol., liii, 1045, 1901.
Genotype—*Mansonia titillans* (Walker). Cat. Brit. Mus., Dipt., 1: 5, 1848.
Subgenus Mansonia Blanchard. C. R. Soc. de Biol., 53: 1045, 1901.
Genotype—*Mansonia titillans* (Walker). Cat. Brit. Mus., Dipt., 1: 5, 1848.

#### **Mansonia titillans** (Walker).

(Female Hypopygium, Plate V, Figs. 39 and 40.)

*Mansonia titillans* (Walker). Cat. Brit. Mus., Dipt., 1: 5, 1848.

Cerci long, somewhat cylindrical, clasper-like in appearance, distal half dilated, the apices bent somewhat medially, basal half narrow and fused to lateral plates of tenth tergite. Postgenital plate two-thirds the length of cerci, emarginate at apex, distal half elliptical, basal half forming a wide stalk-like pedicel fused anteriorly with the combined cowl and ninth sternite; apical setae long, at least five in each lateral group, below these, two groups of at least twelve subapical setae. Cowl conspicuous, lightly sclerotized, fused to posterior margin of ninth sternite, lateral extremities expanded and incompletely articulated with lateral extremities of ninth tergite. Ninth sternite lightly sclerotized, of equal width throughout; lateral extremities bent medially, terminating in saber-like processes with handles fused to extremities of sclerite and

free blades extending medially. Insula plate absent. Eighth tergite armed at each posterolateral shoulder with a large group of stout heavily sclerotized spines, posteromedial mound supporting a single row of heavily sclerotized spines. Ninth tergite wide, of approximately equal width throughout. Tenth tergite represented by lateral sclerotized plates intimately fused with bases of cerci. Anal segment lightly sclerotized, funnel-shaped.

### Subgenus **Rhynchotaenia** Brethes.

Genus Mansonia Blanchard. C. R. Soc. de Biol., 53: 1045, 1901.
Genotype—*Mansonia titillans* (Walker). Cat. Brit. Mus., Dipt., 1: 5, 1848.
Subgenus Rhynchotaenia Brethes. Anal. Mus. Nac. Buenos Aires, (Ser. 3), 13: 470, 1911.
Genotype—*Mansonia fasciolata* (Brethes). Anal. Mus. Nac. Buenos Aires, (Ser. 3), 13: 470, 1911.

#### **Mansonia nigricans** (Coquillett).

(Female Hypopygium, Plate V, Figs. 37 and 38.)

*Mansonia nigricans* (Coquillett). Proc. Ent. Soc. Wash., 6: 166, 1904, (Taenior hynchus).

Cerci long, compressed, inner margins straight; outer margins straight, but rounded apically to form acute angles with inner margins, concaved basally. Postgenital plate elliptical, one-half the length of cerci, fused basally to ninth sternite; supporting two groups of three long apical setae, below these, two groups of five long subapical setae. Cowl absent. Ninth sternite narrow, ribbon-like, bowed, well sclerotized, extending laterally to ventral extremities of the ninth tergite. Sigma absent. Insula plate located medially on preatrial membrane and clothed with numerous fine setae. Ninth tergite narrow laterally, wider dorsally, anterior margin regular; posterior margin broken medially by deep V-shaped cleft flanked on either side by a group of five long setae, lateral extremities extending somewhat ventrally to form loose articulation with extremities of ninth sternite. Anal segment membranous, conspicuous, bell-shaped; expanded anteriorally, and continuous laterally with bases of cerci.

### Genus **Deinocerites** Theobald.

Genus Deinocerites Theobald. Mon. Culic., 2: 215, 1901.
Genotype—*Deinocerites cancer* Theobald. Mon. Culic., 2: 215, 1901.

#### **Deinocerites cancer** Theobald.

(Female Hypopygium, Plate IV, Figs. 23 and 24.)

*Deinocerites cancer* Theobald. Mon. Culic., 2: 215, 1901.

Cerci long, cylindrical, apices surmounted by a pair of long stout setiferous appendages, inner margins straight, outer margins strongly convex basally and slightly concave distally. Postgenital plate short, broad, one-fifth the length of cerci; anterior and posterior borders concave. Cowl absent. Ninth sternite composed of a heavily sclerotized saddle-shaped transverse plate, and two broad, lightly

sclerotized, curtain-like lateral portions which extend anterolaterally; a stout spine projects medially from the inner margin of each curtain-like structure. Insula plate absent. Ninth tergite divided medially into two curved elongate plates, outer margins distinctly flanged. Tenth tergite composed of a small median shield-shaped plate, united by narrow sclerotized bridges to larger lateral triangular plates. Anal segment small, membranous, terminating in conspicuous conical prominence.

## Subgenus **Mochlostyrax** Dyar and Knab.

Genus Culex Linnaeus. Syst. Nat., Ed. X, 602, 1758.
Genotype—*Culex pipiens* Linnaeus. Syst. Nat., Ed. X, 602, 1758.
Subgenus Mochlostyrax Dyar and Knab. Jour. N. Y. Ent. Soc., 14: 223, 1906.
Genotype—*Culex caudelli* (Dyar and Knab). Jour. N. Y. Ent. Soc., 14: 223, 1906.

### **Culex inhibitator** Dyar and Knab.

(Female Hypopygium, Plate V, Figs. 30, 31 and 32.)

*Culex inhibitator* Dyar and Knab. Jour. N. Y. Ent. Soc., 14: 216, 1906.

Cerci short, compressed, truncate, of approximately equal width throughout, inner margins slightly convex; outer margins straight laterally, rounded at apices, sharply concaved basally. Postgenital plate one-half the length of cerci, margins gradually diverging to form a broad base; apex ovate, supporting two groups of four apical setae each, below these, two groups of five subapical setae each. Cowl uniform in width, extending anterolaterally between extremities of ninth sternite and bases of cerci. Ninth sternite narrow, ribbon-like, bowed, well sclerotized; posterior margin supporting (at lateral extremities) small triangular plate, the apices forming loose articulations with extremities of ninth tergite; anterior margins (at lateral extremities) supporting larger triangular plates, the apices of which extend medially. Sigma narrow laterally, continuous with broad preatrial membrane which supports a large median group of fine setae. Ninth tergite consisting of two lateral portions united dorsomedially by a narrow bar, each half narrow laterally, gradually widening dorsally, posterior margins flanged and supporting eleven long radiating setae. Anal segment concave, continuous ventrally with basal half of postgenital plate and dorsolaterally with bases of cerci.

## Subgenus **Melaconion** Theobald.

Genus Culex Linnaeus. Syst. Nat., Ed. X, 602, 1758.
Genotype—*Culex pipiens* Linnaeus. Syst. Nat., Ed. X, 602, 1758.
Subgenus Melanoconion Theobald. Mon. Culic., 3: 238, 1903.
Genotype—*Culex atratus* Theobald. Mon. Culic., 2: 55, 1901.

### **Culex antillum-magnorum** Dyar.

(Female Hypopygium, Plate V, Figs. 33 and 34.)

*Culex antillum-magnorum* Dyar. Mosq. of the Amer., Carnegie Inst., Wash., No. 387, 1928.

Cerci short, compressed, truncate, inner margins strongly concave, outer margins convex apically, concave basally, the cerci approaching in appearance that of a broadly stalked clasper. Postgenital plate equal in length to cerci, lateral margins diverging slightly toward the base, which is fused to ninth sternite, apex truncate, supporting two pairs of long apical setae, below these, two groups of three or four short spine-like subapical setae obliquely aligned. Cowl inconspicuous. Ninth sternite irregular in outline, posterior margin bowed and heavily sclerotized; the lightly sclerotized, shelf-like, median expansions of the anterior margin doubly concaved, clefted at the junction of the concavities, posterior concavities (on either side) each contain a ladle-shaped sclerotization. Insula plate located medially on preatrial fold, supporting a group of ten fine setae. Sigma absent. Ninth tergite wide dorsally, the narrow lateral extremities extend ventrally, and form loose articulations with extremities of ninth sternite, anterior margin regular, posterior margin widely bilobed, each lobe supporting a group of four fine setae. Anal segment concave, continuous anteriorly with postgenital plate, and laterally with the extremities of ninth tergite and the cercal bases.

## Subgenus **Culex** Linnaeus.

Genus Culex Linnaeus. Syst. Nat., Ed. X, 602, 1758.
Genotype—*Culex pipiens* Linnaeus. Syst. Nat., Ed. X, 602, 1758.
Subgenus Culex Linnaeus. Syst. Nat., Ed. X, 602, 1758.
Genotype—*Culex pipiens* Linnaeus. Syst. Nat., Ed. X, 602, 1758.

### **Culex quinquifasciatus** Say.

(Female Hypopygium, Plate IV, Figs. 27, 28 and 29.)

*Culex quinquifasciatus* Say. Jour. Acad. Nat. Sci. Phila., 3: 10, 1823.

Cerci short, compressed, truncate of nearly equal width throughout, outer margins slightly convex, inner margins somewhat concave basally. Postgenital plate equal to cerci in length, lateral margins convex, diverging to form wide base; apex ovate, supporting two longitudinal rows of five long apical setae, below these two rows of three small spine-like setae. Cowl present, margins indefinite. Ninth sternite narrow, ribbon-like, well sclerotized, bowed, posterior margin produced at lateral extremities to form small triangular plates, the apices forming loose articulations with extremities of ninth tergite, anterior margin produced at extremities to form medially projected atrial plates located in posterior wall of atrial chamber. Sigma absent. Insula plate located medially on preatrial membrane, supporting a large group of fine setae. Ninth tergite of equal width throughout, supporting two lateral groups of twelve long stout setae irregularly arranged. Anal segment concave, continuous laterally with undifferentiated membranous cowl, forming (on either side) a wide area bounded ventrally by the extremities of ninth sternite and dorsally by bases of cerci and extremities of ninth tergite.

## Subgenus **Culex** Linnaeus.

Genus Culex Linnaeus. Syst. Nat., Ed. X, 602, 1758.
Genotype—*Culex pipiens* Linnaeus. Syst. Nat., Ed. X, 602, 1758.
Subgenus Culex Linnaeus. Syst. Nat., Ed. X, 602, 1758.
Genotype—*Culex pipiens* Linnaeus. Syst. Nat., Ed. X, 602, 1758.

### **Culex nigripalpus** Theobald.

(Female Hypopygium, Plate V, Figs. 35 and 36.)

*Culex nigripalpus* Theobald. Mon. Culic., 2: 322, 1901.

Cerci short, compressed, truncate, somewhat rectangular, inner margins slightly convex, outer margins gently concaved. Postgenital plate nearly equal to cerci in length, lateral margins diverging to form wide base, apex ovate, supporting two groups of four long apical setae. Cowl indefinite. Ninth sternite narrow, ribbon-like, well sclerotized, V-shaped with apex pointed posteriorly, lateral extremities loosely articulated with extremities of ninth tergite, medially projecting atrial plates produced at extremities and located in posterior wall of atrial chamber. Insula plate crescentic, medially situated on preatrial membrane, and supporting a large group of fine setae. Ninth tergite not extending ventrally, slightly bowed, anterior border shallowly excavated medially; posterior border sharply indented medially, supporting two lateral groups of twelve long stout setae, ten of which are paired. Anal segment concave, continuous ventrally with postgenital plate and dorsally with bases of cerci, continuous laterally with undifferentiated cowl, forming (on either side) a wide membranous area bounded anteriorly and laterally by ninth sternite, and dorsally, by bases of cerci.

## Subgenus **Culex** Linnaeus.

Genus Culex Linnaeus. Syst. Nat., Ed. X, 602, 1758.
Genotype—*Culex pipiens* Linnaeus. Syst. Nat., Ed. X, 602, 1758.
Subgenus Culex Linnaeus. Syst. Nat., Ed. X, 602, 1758.
Genotype—*Culex pipiens* Linnaeus. Syst. Nat., Ed. X, 602, 1758.

### **Culex bahamensis** Dyar and Knab.

(Female Hypopygium, Plate IV, Figs. 25 and 26.)

*Culex bahamensis* Dyar and Knab. Jour. N. Y. Ent. Soc., 14: 210, 1906.

Cerci short, compressed, truncate, approaching clasper-like form, inner margins strongly convex except short basal portion, outer margins convex basally, concaved distally, forming distinct lateral shoulders. Postgenital plate nearly equals cerci in length, lateral margins convex, diverging to form wide base, apex trilobed, median lobe large, lateral lobes minute; two groups of two long coarse apical setae, below these, two groups of five intermediate setae followed by two groups of three small spine-like setae. Cowl indefinite. Ninth sternite narrow, ribbon-like, bowed, heavily sclerotized, produced at lateral extremities to form medially projected atrial plates located in posterior wall of atrial chamber. Sigma absent. Insula plate bar-like, supporting a group of many fine setae. Ninth tergite not extending ventrally,

wide laterally, anterior and posterior margins converging slightly towards the median line, the tergite supporting two lateral groups of seven long coarse setae. Anal segment concave, continuous laterally with the undifferentiated cowl, forming (on either side) a wide membranous area bounded ventrally by extremities of ninth sternite, and dorsally by base of cerci, and lateral extremities of ninth tergite.

## TAXONOMIC VALUE OF THE FEMALE GENITALIA.

The classification of dipterous insects, on the bases of the morphological structures prevalent in the female genitalia, has met with little success. Snodgrass (1903) studied the female genitalia of Tipulidae in an attempt to find morphological characters of specific value. He concentrated his attention upon the highly modified ninth sternite. After examining this sclerite in ten species of the genus Tipula and those found in representatives from several additional genera, he concluded that the minor variations observed were inadequate for specific identification.

Brolemann (1919) carried out preliminary investigations on the female genitalia of Culicidae, involving three species of Theobaldia and four species of Culicada. The structural parts were briefly described and references made to variations prevalent in the postgenital plate and ninth tergite. In his preparations, however, the terminal segments were not sufficiently extended to afford a clear view of the ninth and tenth sternites.

Macfie and Ingram (1922) examined the female genitalia in fifty species of mosquitoes. They included forms from sixteen different genera. Few specific distinctions of consequence were observed because they, like Brolemann, failed to distend the abdomen sufficiently to separate the individual terminal segments.

Christophers (1922–1923) studied the development and morphology of three species from three different genera of the family Culicidae. This work formed the basis for later investigations of the female genitalia in dipterous insects.

Felt (1925) figured several types of female genitalia which occur in the family Itonididae, but made no attempt to utilize the terminal structures of the female in his classification of the "Gall Midges."

Davis (1926) confined his studies to the female Anopheles. His figures indicate that his failure to find variations in the terminal segments may be due to his method of preparation.

Sinton (1927) attempted to utilize the female hypopygium as an aid to specific identification in the genus Phlebotomus, but concluded that the slight variations in the structural parts were inadequate from a taxonomic standpoint.

It is evident that the variations in the terminal structures of the female Culicidae are somewhat restricted by their simplicity, but there is, doubtless, a slight response to the same environmental factors which cause such great diversity of form in the genitalia of the male. Howard, Dyar, and Knab (1912–1917) classified male mosquitoes on the basis

of the morphological variations found in the structural parts of the genitalia, but observed no outstanding group distinctions which might serve in generic separation. I find that the female hypopygia present a striking contrast, in that each generic group possesses certain unique, idiomorphic characteristics which may be utilized in the formation of a generic classification. In addition several promising specific characters have been observed, some of which are not manifest but may be made visible with the aid of a microscope.

## SIGNIFICANT GENERIC CHARACTERS.

In the genus Anopheles, the cerci are of primitive cylindrical type with blunt apices, the inner margins showing only slight modifications in the species here included. Deinocerites possesses long conical cerci, somewhat resembling those of Anopheles, but differing in that the narrow apices support a pair of long setiferous appendages. In Uranotaenia, Wyeomyia, and Culex, the cerci are reduced in length, compressed, truncate apically, and broad basally. The typical cerci of Aedes, and the closely related genus Psorophora, are long, compressed, and leaf-like, with well rounded apices and slightly constricted bases.

The genus Mansonia is exceptional in that the species studied exhibit cerci of two dissimilar forms. In *M. titillans*, these structures are somewhat cylindrical as in Anopheles. The basal halves, however, are restricted, while the distal halves are dilated, somewhat flattened apically, and inclined medially, imparting a clasper-like appearance. In contrast, those of *M. nigricans* are plate-like, and of approximately equal width throughout, suggesting an elongated form of the Culex type. The cerci may be grouped as follows: (1) long, cylindrical cerci, common to Anopheles and Deinocerites; (2) short, plate-like cerci with truncate apices, found in Uranotaenia, Wyeomyia, and Culex; (3) the long, compressed, leaf-like form typical of Aedes and Psorophora.

The postgenital plate, though subject to a wide range of variation even within a single genus, still retains certain outstanding, generic characteristics. In Anopheles the short, triangular, postgenital plate has the semblance of a ventral fold of the anal membrane. Anteriorly, its base merges insensibly with the cowl-like area or membranous tenth sternite. The postgenital plate of this genus, in addition, is characterized by a single pair of long apical setae and the absence of subapical setae. That of the genus Culex is more definite in form. It has a truncate or obtuse apex, wide base, and free lateral margins, but resembles the postgenital plate of Anopheles in being separated basally from the ninth sternite by a similar wide membranous area or cowl.

Uranotaenia and Wyeomyia also possess postgenital plates of a more definite form than those found in Anopheles. In *U. sapphirina*, the apex is bilobed, the base is expanded and intimately fused, with the complete, well sclerotized cowl, and the lateral margins are free. This structure, in *W. vanduzeei*, is truncate at the apex, and narrowed basally where it is fused with the posterior margin of the ninth sternite.

The typical postgenital plate of Aedes and Psorophora is elongate, bilobed or emarginate at the apex, free laterally, and basally constricted.

The narrow base is directly fused to the posterior margin of the ninth sternite as in Wyeomyia.

The genus Mansonia is characterized by an elliptical form of postgenital plate while that of Deinocerites is dumb-bell shaped and is not fused basally to the ninth sternite despite the fact that the cowl is absent. The postgenital plates may be arranged in three main categories: (1) short, triangular or truncate and separated from the ninth sternite by an intervening membranous area as in Anopheles and Culex; (2) short, truncate and fused to the ninth sternite or narrow sclerotized cowl as in Uranotaenia and Wyeomyia; (3) elongate, constricted at the base and fused to the ninth sternite as in Aedes and Psorophora. In addition to the above there is the unusual elliptical form observed in Mansonia and the reduced dumb-bell type noted in Deinocerites.

The cowl, or membranous area intervening between the base of the postgenital plate and the posterior margin of the ninth sternite, is undifferentiated in Anopheles and Culex. In Uranotaenia, however, this structure is well sclerotized, and its margins are definite. That of Wyeomyia, like Aedes, is modified medially to form the basal portion of the postgenital plate, only the lateral parts persisting as membranous areas. Deinocerites, and *Mansonia nigricans* possess an indefinite cowl. In contrast to the latter, *M. titillans* exhibits a narrow, well sclerotized, cowl-like area, fused to the ninth sternite. This area may also be interpreted as the sclerotized posterior margin of the ninth sternite, but the presence of other primitive characters (cylindrical cerci, lateral sclerotized plates of the tenth tergite, and atrial plates) suggest the possible retention of the cowl in a modified form.

The ninth sternite appears less reduced in forms, the larvae of which are subject to a confined environment. This is illustrated by the ninth sternites found in the genitalia of *Aedes albonotatus* (a tree-hole species), *Deinocerites cancer* (a crab-hole dweller), and *Culex antillum-magnorum* (the larva[6] of which has recently been taken in Bromeliads by Dr. J. C. Bequaert). *Mansonia titillans*, whose larva lives on the roots of the water plant Pistia, also has retained a considerable portion of this sclerite together with the more primitive characters previously mentioned.

In the genitalia of Anopheles, the ninth sternite consists of a narrow, transverse sclerotization, and two conspicuous, triangular, atrial plates. These project medially and seem to furnish support to the posterior wall of the atrial cavity.

The characteristic ninth sternite of Culex is narrow and bowed. Its atrial plates extend medially from the lateral extremities and the blunt apices may closely approximate the median crescentic sclerotization which indicates the position of the spermathecal eminence. In Mansonia this sclerite represents two divergent forms. That of *M. titillans* is apparently intermediate between the Anopheles and Culex types, but possesses more highly modified atrial plates. Structures which resemble these atrial plates may be observed, however, in *Culex*

[6]This larval form has not been described to date.

*antillum-magnorum*. The ninth sternite of *M. nigricans* is similar to the typical, uniformly narrow, bowed type of the genus Culex, but differs in that the atrial plates are absent.

Uranotaenia and Wyeomyia have reduced ninth sternites the lateral portions of which are bent anteromedially and all evidence of atrial plates have disappeared. A further modification along this line may be noted in Aedes and Psorophora in which this sclerite has the form of an inverted U and the posterolateral shoulders are usually dilated and well sclerotized. The atrial plates are absent also in these groups. In *Deinocerites cancer* the ninth sternite is unique. It consists of a narrow, heavily sclerotized plate, from which two greatly modified, curtain-like processes extend anterolaterally to form the lateral walls of the atrial cavity. Atrial plates have not been observed in this genus despite its close alliance with Culex.

Although the ninth sternite exhibits gradiating modifications in each genus, a definite structural type usually persists throughout each group. This renders the sclerite particularly useful as a basis for generic classification.

The generic types are as follows: the wide, transverse, ribbon-like form, with large triangular atrial plates, is characteristic of the genus Anopheles; the narrow, bowed, ribbon-like type, with short, blunt, lightly sclerotized, atrial plates prevails in Culex; the narrow, bowed, ninth sternite without atrial plates has been noted in Uranotaenia and Wyeomyia; while the narrow, arched form, lacking atrial plates, but possessing dilated, well sclerotized, posterolateral shoulders, is characteristic of Aedes and Psorophora. That of Deinocerites is highly modified and readily separated from other forms. The ninth sternites noted in the included species of Mansonia are dissimilar and the type characteristic of this genus cannot be determined at this time.

The sigma, when present, is apparently confined to one of two types: (1) that of *Anopheles albimanus*, *Uranotaenia sappharina* and *Wyeomyia vanduzeei*, in which the narrow lateral portions gradually merge anteriorly with a much wider, apron-like, preatrial membrane; and (2) the narrow, ribbon-like form of approximately equal width throughout and continuous anteromedially with the lateral extremities of the bar-like insula plate as found in Aedes and Psorophora. A definite sigma is usually absent in Culex, Mansonia and Deinocerites. The insula plate, however, is often present and is located medially, at the posterior margin of the undifferentiated pre-atrial fold.

The ninth tergite, in some instances, exhibits definite generic characteristics. In Anopheles, Uranotaenia, Wyeomyia, Culex, and Mansonia this sclerite is predominantly of a primitive band-like form, but is subject to minor variations in outline. That of Aedes is typically shield-shaped with indented anterior and posterior margins. The ninth tergite of Psorophora resembles the shield-shaped form (characteristic of Aedes) but appears to have undergone an extreme anteroposterior elongation. *Deinocerites cancer* also has an elongated ninth tergite which is completely divided medially to form two highly modified lateral plates.

The tenth tergite is represented in Anopheles and Wyeomyia by two lateral sclerotized plates which, in the dorsal view, conceal the cercal bases. *Mansonia titillans* possesses a similar incomplete tenth tergite. In the latter case, however, the lateral plates are intimately fused with the basal portions of the cerci.

The anal membrane or proctiger, likewise, exhibits certain generic characteristics. This structure is domed in Anopheles, funnel- or bell-shape in Mansonia, papillaform in Deinocerites, and hood-shape in Aedes. In Psorophora the proctiger is reduced to a narrow concave strip which extends anterio-dorsally from the apex of the postgenital plate to fuse with the bases of the cerci. The characteristic proctiger of Wyeomyia, Uranotaenia, and Culex is also concave, but is greatly obscured by the plate-like cerci and wide postgenital plate.

## CHARACTERS OF SPECIFIC VALUE.

Of the segments involved in the production of the female genitalia, the ninth is undoubtedly the most variable. Though it may persist in a characteristic form throughout each genus it presents many minor variations which should prove of specific value.

In *Anopheles albimanus*, the transverse ninth sternite is slightly bilobed medially, and tapers narrowly toward the lateral extremities, exhibiting a greater modification than that of *Anopheles vestitipennis* which is of equal width throughout. In both species the atrial plates are large, heavily sclerotized, and triangular in shape, but show certain minor variations which may prove to be of specific importance. The ninth sternite of Culex is characteristically narrow and bowed, presenting some specific peculiarities. The appended atrial plates show slight variations and may contribute valuable differential characters. *Mansonia titillans* has a broad ribbon-like ninth sternite with atrial plates which terminate medially in sabre-like sclerotizations. That of *Mansonia nigricans* is narrow and bowed, closely resembling the typical Culex form, but differing in the absence of atrial plates.

The ninth sternite of Aedes is narrow and arched. It varies in the degree of dilation of the posterolateral shoulders, and in the width of the lateral arms. The included species of Psorophora exhibit decided specific variations in the ninth sternite. In *P. columbiae* this sclerite is irregular in outline, the posterolateral shoulders are greatly dilated, and the inner margins of the lateral arms each support a short triangular process which is folded laterally against the ventral surface. In contrast, *P. ferox* has a ninth sternite which is regular in outline, the transverse portion is bar-like and the lateral arms are but slightly expanded. No prophecy may be made, at this time, regarding the variation in the ninth sternites of Uranotaenia, Wyeomyia, and Deinocerites, since but a single species of each genus is here represented.

The ninth tergite is present in all forms studied, and although typically band-like in Anopheles, Uranotaenia, Wyeomyia, Mansonia, and Culex, possesses specific peculiarities of outline. In Wyeomyia, *Mansonia nigricans*, and Culex, this sclerite supports lateral setae-

groups which vary both in number and in arrangement. The shield-shaped ninth tergite of Aedes is variously modified by the notches of the anterior and posterior margins. In addition, characteristic setae-groups crown the lobes of the posterior margin. The species of Psorophora studied also indicate the presence of slight specific variations in this sclerite.

The postgenital plate presents specific peculiarities in general outline, type of apex, relation of the base to the posterior margin of the ninth sternite, and in the number and arrangement of apical and subapical setae. The latter are of questionable specific value because of their unstable condition, regarding their number and arrangement. The apical setae, however, appear to possess sufficient stability to render them useful when combined with other characters of the postgenital plate.

In rare cases, the anal segment may contribute specific characteristics. This may be illustrated by a comparison of the simple, domed, anal membrane of *A. albimanus* with the cratered type of *A. vestitipennis;* the ring-like form of *Aedes taeniorhynchus* with the hood-like membrane of *Aedes sollicitans;* and the funnel-like form of *Mansonia titillans* with the bell-shaped anal membrane of *Mansonia nigricans.*

The sigma, though essentially of two general types, possesses specific distinctions both in outline and in its relations to the insula plate. It may be narrow and bar-like anteriorly as in *Anopheles vestitipennis* or wide and apron-like as in *Anopheles albimanus.* An Apron-like form, similar to that of the latter species, has been observed also in *Wyeomyia vanduzeei,* while in *Uranotaenia sappharina* the wide sigma is heavily sclerotized and forms a hood-like structure to the anterior margin of which the insula plate is fused. In Aedes and Psorophora the sigma is present, but shows no specific variations. Culex and Mansonia possess no definite sigma and the insula plate, when present, is located medially at the posterior margin of the undifferentiated preatrial fold.

The insula plate rarely presents definite specific characteristics. It usually supports a group of insula setae, the number of which varies in different species, but since they are often in the form of a tuft, the exact number present is difficult to determine.

## DEVELOPMENT OF THE FEMALE GENITALIA.

Hurst (1890) observed the development of the terminal structures in the nymphal stage but interpreted only the lateral projections which later were to produce the copulatory appendages. Nuttall and Shipley (1901), as Hurst did, observed the development of the parts in the nymph and attempted to homologize the blunt processes of the ninth segment with the claspers of the male. Christophers (1922), concluded, however, that these appendages of the female were cerci and were present in an undeveloped form in the male. His developmental studies began with the last larval instar where the terminal structures of the sexes differ only in certain thickenings of the dermal layer.

In this stage he found that the ninth tergite is represented by the spiracular parts and, ventrally, the ninth sternite is present as a mere narrow fold. The tenth segment is represented dorsally by a saddle-shaped plate. Ventrally, beyond the ninth sternite, Christophers noted an area under which, in the male, proandropodites (rudiments from which the side pieces form) are developed. In the female, the thickening in practically the same area gives rise to the postgenital plate. The shaping of the structures, as differentiation progresses, is due to a process which Christophers refers to as "developmental shrinkage," a phenomenon which becomes more active in the nymphal stage. As the sexual characters of the nymph gradually became more pronounced, he noted that the thickening behind the ninth sternite of the female nymph gradually forms a shield-shaped plate which in the adult becomes the postgenital plate. The lateral, sclerotized plates which first appeared under either side of the dorsal plate of the larva now project noticeably and are the structures which Nuttall and Shipley homologized with the proandropodites of the male, but which Christophers contends are cerci. At this time he also observed that the cerci did not develop from imaginal buds, but were separated from the original segmental mass by fissures which appeared on either side. The shield-shaped plate, which in the adult female is to become the postgenital plate, was found to be absent in the male nymph while the imaginal buds which appear in the lateral sclerotized plates of the male, and from which the proandropodites arise, are absent in the female.

In an early stage of nymphal development, Christophers observed the presence of a fold which extended between the shoulders of the eighth segment, anterior to the atrial depression, at the center of which the insula plate developed. At this time, he also noted the formation of a second fold located just posterior to the atrial depression, apparently produced as a result of the ingrowth of the postgenital plate rudiment. When these two folds become sclerotized and united, they form the ring-like structure surrounding the atrium. This structure he termed the sigma. Christophers also observed a prominent, spermathecal eminence located within the atrial cavity, from which, on either side certain sclerotized plates extend laterally and fuse to the sigma. These structures, which are conspicuous in Anopheles, he referred to as atrial plates.

## COMPARATIVE MORPHOLOGY OF THE FEMALE GENITALIA.

Recent morphological investigations indicate that the genital structures of the Holometabola resemble, in many respects, those observed in representatives of the superorder Panisoptera[7] (Blattids, Mantids, and Isoptera). The reduction of the suranal plate, or its concealment by a prolonged tenth tergite, and the gradual disappearance

[7]Panisoptera—a super-order appearing in the classification of insects formulated by Crampton (1929). The Terminal Abdominal Structures of Female Insects compared throughout the Orders from the Standpoint of Phylogeny. Jour. N. Y. Ent. Soc., 37, p. 490.

of the ovipositor, are tendencies which may be noted in the latter superorder. These tendencies seem to be consummated in the highest holometabolous insects. Segmented cerci, which are observed frequently in the members of Panisoptera, are likewise common in the lower Trichoptera, Mecoptera and Diptera. The cerci of the higher dipterous insects, when present, usually consist of a single segment.

Crampton (1929) concluded that the Mecoptera descended from the common stock which gave rise to the Neuroptera and Hymenoptera. The Mecoptera, however, have retained the terminal abdominal segments in a more primitive condition than those found in either Neuroptera or Hymenoptera. In a series of papers appearing from 1917 to 1926, Crampton demonstrated the unusual morphological resemblances existing in the head, maxillae, labium, neck and prothorax, mesonotum and male genitalia of Mecoptera and Diptera. Therefore, it is plausible to expect the female genitalia of the Nematocera (lower dipterous insects) to approach the primitive condition observed in the terminal abdominal segments of Mecoptera.

Because of the close alliance between Diptera and Mecoptera, it seems unnecessary to devote more than a very brief discussion to the dipterous line of descent. In the lower Hymenoptera (Tenthredinidae)[8] the eleventh segment is represented by a membranous proctiger and small unsegmented cerci. A well developed ovipositor has been retained, apparently to the detriment of the tenth and eleventh abdominal segments. The primitive Raphidiidae of the Neuroptera also have retained a long ovipositor and the reduced eleventh segment, though represented in the adult, has lost both the sternite and the cerci. A vestigial eleventh tergite persists and is intimately fused with the posterior margin of the narrow tenth tergite. In other neuropterous forms the eleventh segment is not evident, the cerci are absent and the ovipositor, when present, is usually vestigial.

One finds in Trichoptera (an order closely allied with the Neuroptera) two main types of genitalia; first, the compact type characteristic of the more specialized families in which the terminal segments are greatly reduced, and neither the cerci nor the ovipositor are present; second, the elongate type common to the less specialized Rhyacophilidae. Individuals of the latter family possess elongate terminal abdominal segments which have become membranous. This is undoubtedly due to their withdrawal within the eighth segment. In Rhyacophila[9] (Fig. 41) the eleventh sternite is absent as in Raphidia. Small membranous, segmented cerci (CE), however, are present and are separated basally by a sclerotized triangular plate (SA). The latter structure may be homologized with the suranal plate (eleventh tergite) noted in the Raphidiidae and many lower insects. The reduced cerci are similar to those of Panorpa (Fig. 42) in respect to dorsal position, segmentation, and enlarged basicerci (BC). In Panorpa (Fig. 42) the

[8]This family includes more than seven-eighths of the generalized hymenopterous insects grouped in the suborder Chalastogasteroidea.

[9]The abdomen here, is not completely extended; the ninth segment is still within, and concealed by the large eighth segment.

suranal plate is absent and the cerci have rotated dorsad sufficiently to allow for partial fusion of the basicerci. This results in the formation of a synbasite[10] which, from the dorsal aspect, resembles an incompletely divided tergite. Each cercus (CE) consists of a large, plate-like basicercus (BC) followed by two short, cylindrical segments of approximately equal length. One may observe in Panorpa (Fig. 42) a small, bilobed, lightly sclerotized, eleventh sternite which opposes the synbasite. The eleventh of *Merope tuber*[11] and Boreus, though similar in many respects, are yet slightly more elongate, and triangular in shape.

All of the several species of Panorpa that I have examined, exhibit small membranous, cone-like, anal papillae (AP) located between the eleventh sternite and the synbasite. That the cerci, anal papilla, and sternite represent an eleventh segment is indicated by the fact that collectively, they form a terminal abdominal area which is definitely separated from the tenth segment by an intersegmental membrane. This is readily seen only when the abdomen is dilated as in Panorpa (Fig. 42).

A comparison of the terminal structures of Mecoptera with those of the Nematocera should demonstrate the manner in which reduction and incorporation of the terminal segments have served in the production of a compact type of genitalia commonly observed in the Culicidae. By the same method, I have attempted to determine the origin of certain structural parts which in some instances have migrated from their original location and, in others, are represented by mere vestiges.

The segmented cerci (CE) of the Mecopteron (Fig. 42) are composed of a large, slightly compressed basicerci (BC) followed by two short, cylindrical segments, and are similar in many respects to those found in the Nematocera. Those of the Bibionid (Fig. 49) and Macrochile[12] have lost the small terminal segment and there remains only the well compressed basicercus (BC), and a single cylindrical disticercus (DC). In the Mycetophilids (Figs. 45 and 46) one likewise finds segmented cerci composed of a large slightly compressed basicerci and a disticercus which also has become compressed and is elliptical in outline. This latter form has been noted also in some species of Itonididae,[13] Rhagionidae[14] and Asilidae.[15]

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[10]Synbasite—a term used by Crampton (1929). The Terminal Abdominal Structures of Female Insects compared throughout the Orders from the Standpoint of Phylogeny. Jour. N. Y. Ent. Soc., 37, p. 487.

[11]Dr. G. C. Crampton generously extended to the author the privilege of examining a female specimen of the rare Merope tuber.

[12]See Crampton, G. C. (1926). The External Anatomy of the Primitive Tanyderid Dipteron Macrochile Preserved in Amber. Bull. Brook. Ent. Soc., 21, Plate I, Figure 8.

[13]See Felt, E. P. (1925) Key to the Gall Midges. N. Y. State Museum Bull., No. 257, Fig. 36.

[14]See Crampton, G. C. (1929) The Terminal Abdominal Structures of Female Insects compared throughout the Orders from the Standpoint of Phylogeny. Jour. N. Y. Ent. Soc., 37, Plate XVI, Figure 911.

[15]Ibid, Plate XVI, Figure 101.

The primitive Tanyderid Macrochile possesses segmented cerci which consist of a large compressed basicercus and a small conical disticercus. That of the Tanyderid Protoplasa (Fig. 52) has retained only the compressed basicercus, the small terminal segment having disappeared.

The large, compressed, unsegmented cerci of the lower Tipulids were probably derived from the Macrochile type by a similar elimination of the small terminal segment. In the primitive Liogma[16] (Fig. 53), the disticerci are absent. The basicerci (BC) are wide, partially compressed and well rounded apically. Prionocera[17] (Fig. 54) indicates a stage, intermediate in the series of modifications which ultimately culminates in the long, slender, unsegmented cerci observed in the more specialized Tipulids. In Prionocera (Fig. 54), the basicerci are broad and well compressed. The inner marginal areas, however, are prolonged posteriorly to form narrow finger-like processes. Continued elongation of these processes concomitant with the smoothing out of the lateral margins has resulted in the production of the type of cerci found in Tipula (Fig. 48). This form is characteristic of the higher Tipulidae.

Some of the more specialized families of the Nematocera exhibit large, compressed unsegmented cerci, which appear to have been derived (in like manner) from plate-like basicerci similar to those of Macrochile and homologous to the somewhat cylindrical basicerci (BC) noted in the Mycetophilid (Fig. 46) and Panorpa (Fig. 42). In the lower Culicidae a cylindrical form of basicerci is retained, as illustrated by Corethra (Fig. 51) and Anopheles (Fig. 1). Similar unsegmented cylindrical cerci have been observed in ***Bittacus nipponicus***.[18] In the latter species the terminal segments are reduced as in Trichocera (Fig. 44) and form a more compact hypopygium than that of Panorpa (Fig. 42). Both Bittacus and Trichocera show an advance over Panorpa in membranization of the tenth sternite and reduction of the intersegmental membrane between the tenth and eleventh segments. As a result of this reduction the eleventh sternite (PG) is closely applied basally to the posterior margin of the tenth sternite.

In the Mycetophilid (Fig. 46), the ninth segment is somewhat abbreviated. Here the tenth sternite is entirely membranous and continuous with the wide membranous eleventh sternite (PG). The Mycetophilid (Fig. 45) shows a further reduction of the ninth segment which, with the telescoping of the tenth segment within the ninth, has resulted in the nearly complete exposure of the composite postgenital plate.

A somewhat different modification of the terminal segments has taken place in the Tipulidae. In this family, the ninth segment has undergone a decided reduction as in the Ptychopterid (Fig. 43) and Trichocera (Fig. 44). The tenth segment, however, is elongate as in

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[16]A genus of the subfamily Cylindrotominae, representatives of which were found to be numerous in the White River beds of the Eocene.

[17]A genus of the primitive subfamily Tipulinae.

[18]Miyake, T. (1913), Studies on the Mecoptera of Japan. Jour. College Agri., Imp. Univ. Tokyo, 6, Plate 31, Figure 2.

Panorpa (Fig. 42), but differs in that the sternite is completely membranous. The intersegmental membrane between the tenth and eleventh segments has been reduced, and the eleventh sternite is fused basally with the posterior margin of the membranous tenth sternite. This is shown by Tipula (Fig. 48) in which the eleventh sternite (PG) is continuous with the tenth as in the Mycetophilid (Fig. 46) and Trichocera (Fig. 44).

The postgenital plate of Prionocera (Fig. 54) is large and indicates a tendency to migrate forward upon the membranous tenth sternite. In the specialized groups of the Tipulidae, the forward migration of the eleventh sternite or postgenital plate is more pronounced, and in representatives of the genus Erioptera which I have examined, the eleventh sternite has (in addition to its forward migration) divided medially, thus producing two fan-shaped structures which may be mistaken for modified limb appendages of the tenth segment. The tendency of the eleventh sternite or postgenital plate to divide medially is not confined to the Tipulidae.

In the Tanyderid Protoplasa (Fig. 52) the postgenital plate (PG) exhibits a decided weakening along its median line. The Dixid (Fig. 56) has a completely divided postgenital plate whose base is loosely articulated with the posterior margin of the ninth sternite. The tenth sternite is not evident, but is probably represented by the enlarged basal portion of the postgenital plate, a view which will be substantiated by forthcoming evidence.

The fusion of the eleventh and tenth sternites resulting in the production of a large, well defined postgenital plate is clearly demonstrated in the Culicidae. In Anopheles (Fig. 1) the eleventh sternite is present and appears as little more than a poorly defined ventral fold of the anal membrane or proctiger. It is separated basally from the ninth sternite by a wide, membranous tenth sternite or cowl.[19] This area is continuous laterally with the sclerotized tenth tergite. Anopheles (Fig. 3) exhibits a more clearly defined postgenital plate (PG) which has encroached upon, reducing in width, the membranous tenth sternite or cowl.

Representatives of the genus Culex (as in those of Anopheles) have retained a membranous cowl which intervenes between the base of the postgenital plate (PG) and the ninth sternite, as illustrated by *C. nigripalpus* (Fig. 35). The cowl shows a slight differentiation in some species. That of *C. inhibitator* (Fig. 30) may be easily seen only in well dilated specimens for under natural conditions, this membranous area is infolded at the posterior margin of the ninth sternite as shown in Fig. 31.

The morphological similarities in Anopheles and Culex are evident, and *Mansonia titillans* (Fig. 39) heralds a close relationship between these genera. Although the genus Mansonia is closely allied to Culex the female genitalia of *Mansonia titillans* exhibits several primitive

[19] A term coined by Christophers (1923). The Structure and Development of the Female Genital Organs and Hypopygium of the Mosquito. Ind. Jour. Med. Res. X, No. 3, p. 702 and Plate XXXVIII, Figure 12.

characters typical of Anopheles, i. e., cylindrical cerci, presence of a tenth tergite, dilated proctiger, and wide transverse ninth sternite with atrial plates. In addition, this species possesses a highly differentiated cowl which resembles the form characteristic of Aedes. In Mansonia (Fig. 39), this structure is sclerotized along its entire anterior margin. The median portion also is sclerotized and constitutes the pedicel-like base of the postgenital plate. On either side of the pedicel, the remaining lateral portions of the cowl are present as membranous folds.

A continuation of this modification may be observed in Aedes, as illustrated by Figs. 9, 13 and 15, where the sclerotized median area of the cowl closely approximates in width that of the eleventh sternite, and the line of fusion between the eleventh and tenth sternites is represented by a slight constriction located about half way between the base and the apex of the composite postgenital plate. The membranous lateral folds of the cowl, so conspicuous in *Mansonia titillans* (Fig. 39) are usually reduced in Aedes, but may be determined in Aedes (Fig. 10), where they have flattened out to form smooth membranous areas, continuous laterally with the hood-like anal membrane.

The final stage may be observed in Psorophora[20] (Fig. 19). In this group the postgenital plate resembles that of Aedes, but is less heavily sclerotized. Here the entire tenth sternite (or cowl) is involved in the formation of the expanded basal portion of the postgenital plate, and the median sclerotized area is reduced to a narrow, vertical, sclerotized stripe. The line of fusion between the eleventh and tenth sternites (represented by lateral constrictions in the postgenital plate of Aedes) is here represented by a conspicuous transverse fold.

The anal membrane, or proctiger, is small and papilliform in Panorpa (Fig. 42). The broad, dorsally-located, basicerci (BC) and the opposing eleventh sternite (ST) apparently have restricted the expansion of this area. A similar restriction obtains in the Nematocera, which possess broad dorsal basicerci directly opposed by the postgenital plate as illustrated by Trichocera (Fig. 44), the Mycetophilids (Figs. 45 and 47), and the Tipulids (Figs. 48 and 54).

Forms which have reduced lateral cerci usually show a greater development of the anal membrane. In *Bittacus nipponicus*[21] the small, conical cerci are separated by a large, crater-like proctiger. Protoplasa (Fig. 52) has a similar membranous structure, but differs in that the fan-like cerci are actually mounted upon this area. Anopheles (Fig. 3) also resembles Bittacus in possessing laterally-located, cylindrical cerci and an extensive proctiger. In Anopheles, as in Protoplasa, the cerci are situated on the anal membrane. *Mansonia titillans* (Fig. 40), a species which appears to be intermediate between Anopheles and Culex, exhibits a large funnel-shaped proctiger somewhat constricted basally. As a consequence, the highly modified cylindrical cerci are fused with, and derive support from, the lateral sclerotized plates of the tenth

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[20]A genus more specialized than, but allied to Aedes.

[21]Miyake, T. (1913), Studies on the Mecoptera of Japan. Jour. College Agri., Imp. Univ. Tokyo, 6, Plate 31, Figure 2.

tergite. *Mansonia nigricans* (Fig. 38), however, has retained an extensive bell-shaped proctiger which is broad basally and supports the compressed Culex-like type of cerci present in this species.

Deinocerites[22] (Fig. 24), like *Mansonia titillans* (Fig. 40), has cylindrical cerci and a tenth tergite as in Anopheles. In the former, the large cercal bases appear to have checked the expansion of the central membrane, resulting in the retention of a small, papillaform proctiger like that observed in Panorpa (Fig. 42). In Wyeomyia, Uranotaenia[23] and Culex, the broad, dorsal cerci and opposing postgenital plate have likewise inhibited the expansion of the proctiger, which in these genera is characteristically of small area, concave and somewhat concealed. The narrow leaf-like cerci of Aedes are not strictly lateral in position, but are sufficiently compressed to allow for a ventral and lateral expansion of the anal membrane, thus this area becomes hood-like in form. In Aedes (Fig. 12) one may observe a hood-like proctiger which has retained a crater-like apex previously noted in some of the lower Culicidae. In Anopheles and Culex the structural similarities are rather striking, and in addition, *Mansonia titillans* seems to herald a close relationship between these genera.

The tenth segment in Panorpa (Fig. 42), is annular and well sclerotized, excepting a small median, V-shaped area of the sternite. In Trichocera (Fig. 44), this membranous area has increased in size and, in most other Nematocera, has involved the entire tenth sternite as shown in Protoplasa (Fig. 52) and the Mycetophilad (Fig. 46). In a similar manner, the tenth tergite is gradually reduced and finally disappears entirely as shown by the higher Culicids. This sclerite is large and completely sclerotized in most Tipulids, but in other Nematocera indicates a tendency to become membranous medially as shown by Protoplasa (Fig. 52), Prionocera (Fig. 54), and the Bibionid (Fig. 49). That of Anopheles (Fig. 2), Wyeomyia (Fig. 6), and Mansonia (Fig. 40), shows an increase in membranization medially, and as a result, the tenth tergite is represented by two small, lateral, sclerotized plates. Uranotaenia, Culex, Aedes, and Psorophora possess no discernible tenth tergite, though the sternite or cowl is usually represented in a modified form. In some genera of the Culicidae, as previously enumerated, a median sclerotized portion of the cowl (tenth sternite) fuses with the eleventh sternite and forms a composite postgenital plate. The lateral areas of the cowl may persist as membranous folds (shown in Mansonia, Fig. 39), but in Psorophora they have entirely disappeared.

The ninth segment is subject to considerable variation, doubtless due to its proximity to the genital aperature located in the membranous area between the eighth and ninth sternites. The tergite is typically band-like in most Nematocera, but, in some instances, is shield-shaped, as in the Dixid (Fig 56) and the chironomid (Fig. 55), where it functions as a dorsal shield for the terminal abdominal appendages. A similar

[22]A genus allied to Culex.

[23]A genus allied to Anopheles.

shield-shaped ninth tergite may be observed in Aedes and Psorophora; more elongate in the latter.

The ninth sternite usually serves as a framework, supporting the margins of the genital aperature. A simple, basic, yoke-like type is present in Prionocera (Fig. 54) and in the Dixid (Fig. 56). The progressive modification of this sclerite, as shown in the lower Tipulids, seems to parallel that which has occurred in the Culicidae. For this reason the ninth sternite, as found in some of the more primitive Tipulids, may indicate the manner in which reduction and modification has taken place in the Culicidae.

The anterior projections (A) of the ninth sternite of Prionocera (Fig. 54) are homologous to similar processes of the ninth sternites found in Dixid (Fig. 56), Culex (Fig. 33), and Aedes (Fig. 17). In Culicidae, however, the lateral extremities of this sclerite are bent anteromedially, thus throwing these processes into a horizontal plane. The type of sclerite which results from this modification may be observed in Culex (Fig. 33), and in Aedes (Fig. 17). In the former, the bowing and reduction of the transverse portion, and a modification of the processes to form atrial plates, is shown by a comparison of Culex (Fig. 33) with Culex (Fig. 30). A similar bowing and reduction of this sclerite has taken place in Aedes. The atrial plates, however, are entirely reduced in most forms, as illustrated by comparing Aedes (Fig. 17) with Aedes (Fig. 15). The bowing, reduction in width, and loss of the atrial plates has resulted in an inverted U-shaped sclerite with enlarged posterolateral shoulders.

The transverse ninth sternite with large, triangular atrial plates (as found in Anopheles, Fig. 1, is the result of a slightly different line of modification. In comparing Prionocera (Fig. 54) with Tipula (Fig. 48), one may observe that, in the latter species, the sternite is not greatly reduced medially, as in the former. In Tipula (Fig. 48) this sclerite is wide medially and bent to form a collar which partially surrounds the posterior end of the spermathecal tube. The medial buckling of the sclerite, to form a collar, has carried the apices of the process (A) nearer to the median line. In the Mycetophilid (Fig. 45), a continuation of this modification has resulted in the fusion of these processes apically, bringing about the complete closure of the collar ventrally.

In Anopheles (Fig. 3), and Mansonia (Fig. 39), the ninth sternite resembles the collar-like form noted in the Tipulid (Fig. 48); the flexure, however, is slight and the apices of the atrial plates are not carried sufficiently near the median line to allow for fusion.

## CONCLUSIONS.

(1) The genitalia of female mosquitoes exhibit outstanding morphological variations which are of generic significance.

(2) Specific variations also are present in the genitalia of the included species.

(3) The eleventh abdominal segment is present in female

mosquitoes. This segment comprises the cerci, the proctiger, and at least a portion of the postgenital plate.

(4) The postgenital plate is, in most instances, a composite structure, produced by fusion of the sternite of the eleventh segment with that of the tenth segment.

(5) The tenth tergite is represented in the female genitalia of the lower Culicids, but is not discernible in the more specialized forms.

(6) The tenth sternite, though present, is greatly reduced and is most often membranous.

(7) The ninth sternite is always present and is usually well sclerotized.

(8) The atrial plates, when present, are derived from the ninth sternite.

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## EXPLANATION OF PLATES.

PLATE I.—Female Genitalia.

Ventral and lateral views of composite genitalia.

PLATE II.—Female Genitalia.

Fig. 1. Ventral view of *Anopheles albimanus*. Fig. 2. Dorsal view of same. Fig. 3. Ventral view of *Anopheles vestitipennis*. Fig. 4. Dorsal view of same. Fig. 5. Ventral view of *Wyeomyia Vanduzeei*. Fig. 6. Dorsal view of same.

PLATE III.—Female Genitalia.

Fig. 7. Ventral view of *Uranotaenia sappharina*. Fig. 8. Lateral view of same. Fig. 9. Ventral view of *Aedes sollicitans*. Fig. 10. Lateral view of same. Fig. 11. Ventral view of *Aedes taeniorhynchus*. Fig. 12. Lateral view of same. Fig. 13. Ventral view of *Aedes tortilis*. Fig. 14. Lateral view of same. Fig. 15. Ventral view of *Aedes aegypti*. Fig. 16. Lateral view of same. Fig. 17. Ventral view of *Aedes albonotatus*. Fig. 18. Lateral view of same.

PLATE IV.—Female Genitalia.

Fig. 19. Ventral view of *Psorophora columbiae*. Fig. 20. Lateral view of same. Fig. 21. Ventral view of *Psorophora ferox*. Fig. 22. Lateral view of same. Fig. 23. Ventral view of *Deinocerites cancer*. Fig. 24. Dorsal view of same. Fig. 25. Ventral view of *Culex bahamensis*. Fig. 26. Dorsal view of same. Fig. 27. Ventral view of *Culex quinquifasciatus*. Fig. 28. Dorsal view of same. Fig. 29. Lateral view of same.

PLATE V.—Female Genitalia.

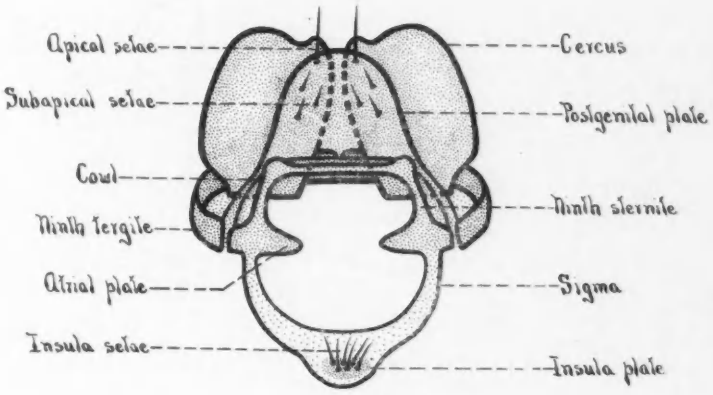
Fig. 30. Ventral view of *Culex inhibitator*. Fig. 31. Lateral view of same. Fig. 32. Dorsal view of same. Fig. 33. Ventral view of *Culex antillummagnorum*. Fig. 34. Dorsal view of same. Fig. 35. Ventral view of *Culex nigripalpus*. Fig. 36. Dorsal view of same. Fig. 37. Ventral view of *Mansonia nigricans*. Fig. 38. Dorsal view of same. Fig. 39. Ventral view of *Mansonia titillans*. Fig. 40. Dorsal view of same plus eighth tergite.

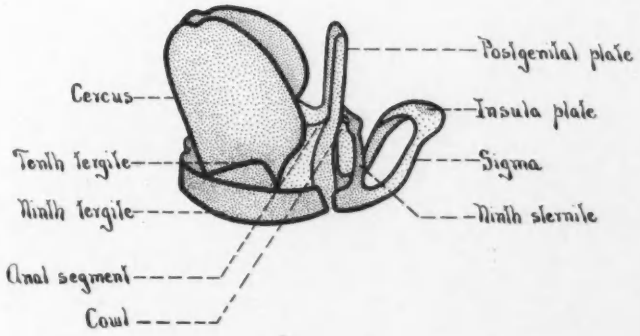
PLATE VI.—Female Genitalia.

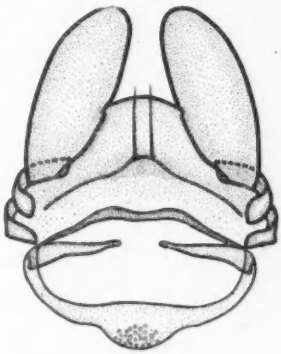
Fig. 41. Dorsal view of Trichopterid (*Rhyachophila* sp.). Fig. 42. Ventral view of Mecopteron (*Panorpa signifer* Banks). Fig. 43. Ventral view of Ptychopterid (*Ptychoptera rufocincta* O. S.). Fig. 44. Ventral view of Anisopid (*Trichocera* sp.). Fig. 45. Lateral view of Mycetophilid (*Acnemia flaveola* Coq.). Fig. 46. Ventral view of Mycetophilid (*Macrocera* sp.). Fig. 47. Lateral view of same. Fig. 48. Ventral view of Tipulid (*Tipula ultima* Alex.). Fig. 49. Dorsal view of Bibionid (*Plecia heteroptera* Say). Fig. 50. Ventral view of same. Fig. 51. Ventral view of *Corethra albipes* Johannson. Fig. 52. Ventral view of Tanyderid (*Protoplasa fitchii* O. S.). Fig. 53. Ventral view of Tipulid (*Liogma* sp.). Fig. 54. Ventral view of Tipulid (*Prionocera* sp.). Fig. 55. Ventral view of typical Chironominae. Fig. 56. Ventral view of Dixid (*Dixa* sp.).

ABBREVIATIONS USED ON PLATE VI.

A—atrial plate.
AP—anal papilla
BC—basicercus.
CE—cercus.
DC—disticercus.
P—processes of ninth segment.
PG—postgenital plate.
SA—suranal plate.
SP—spermathecal aperture.
ST—sternite.
TG—tergite.


Apical setae
Subapical setae
Cowl
Ninth tergite
Atrial plate
Insula setae
Cercus
Postgenital plate
Ninth sternite
Sigma
Insula plate


Cercus
Tenth tergite
Ninth tergite
Anal segment
Cowl
Postgenital plate
Insula plate
Sigma
Ninth sternite



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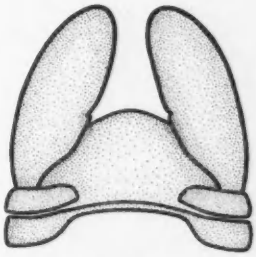

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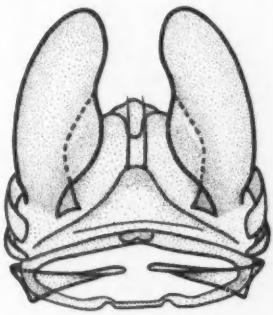

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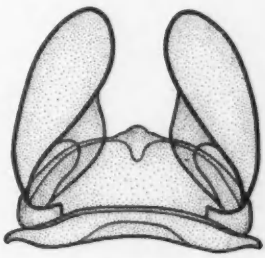

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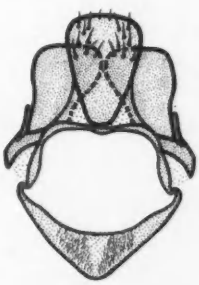

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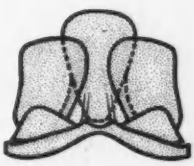

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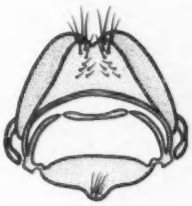
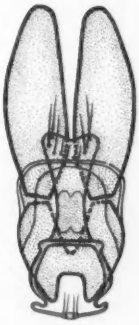


*Fig. 7*

*Fig. 8*

*Fig. 9*

*Fig. 10*



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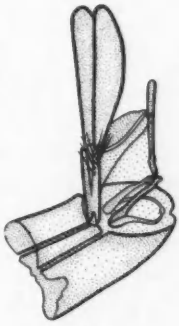

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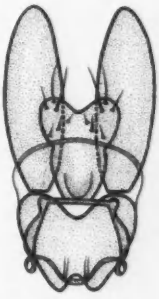
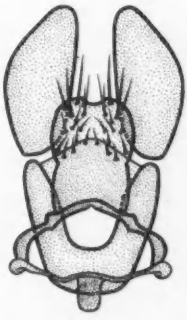


*Fig. 13*

*Fig. 14*



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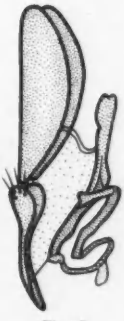

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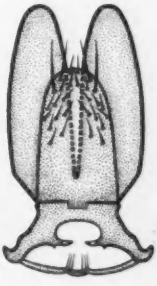


*Fig. 17*

*Fig. 18*

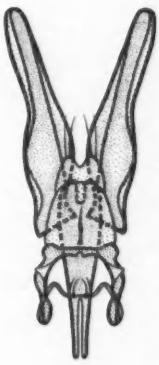


Fig. 19

Fig. 20

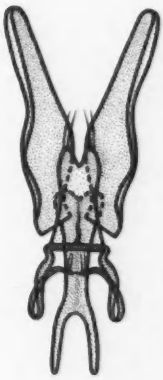
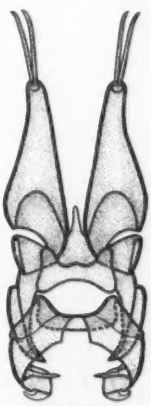


Fig. 21

Fig. 22



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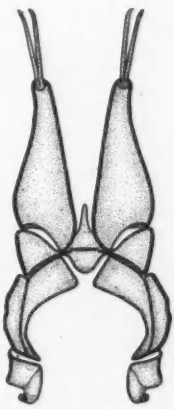

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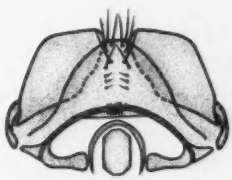

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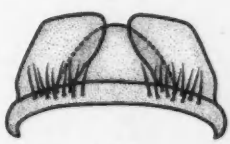

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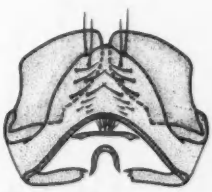

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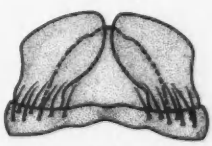


Fig. 26

Fig. 29

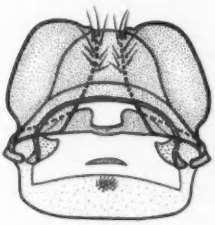
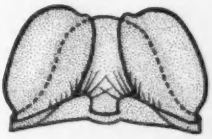


*Fig. 30*

*Fig. 31*



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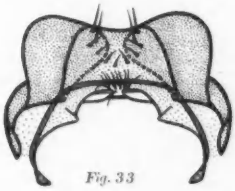

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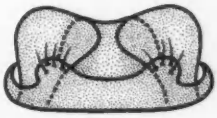

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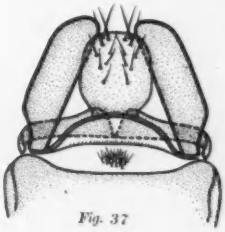
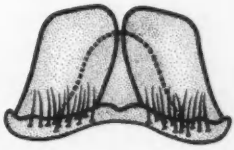


*Fig. 37*

*Fig. 35*



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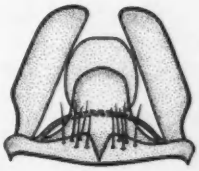

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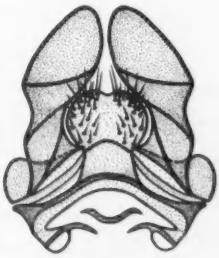

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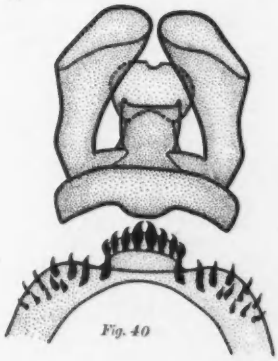
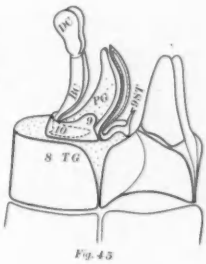


*Fig. 40*

Fig. 41



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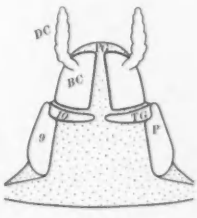

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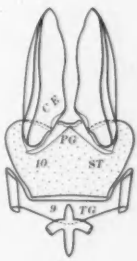
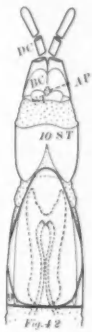


Fig. 53



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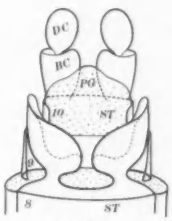

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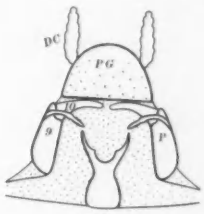
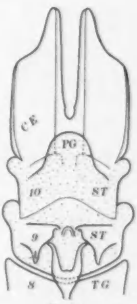


Fig. 50



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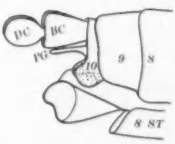

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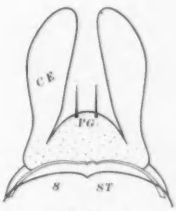

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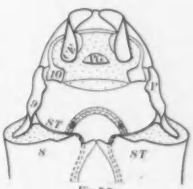

Fig. 55

Fig. 44

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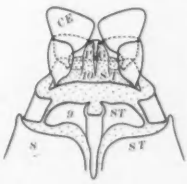

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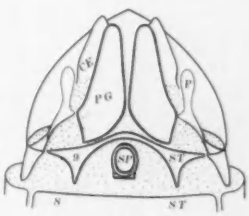

Fig. 56

# THE MYRMECOCOLES OF LASIUS UMBRATUS MIXTUS APHIDICOLA WALSH.[1]

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Over sixty years have passed since Brendel (1865) described the North American clavigerid, *Adranes lecontei*. Although the species obviously should have interesting interrelations with its hosts (species of *Lasius*), nothing is known of its life history or of the details of its position in the *Lasius* biocoenose (Wheeler, 1926, p. 405). Instead, we have drawn from accounts of better known related forms, especially the European *Claviger testaceus* Preys. The latter has been studied by many workers, and our knowledge of this species is summed up by Müller (1818), Hetschko (1896), Krüger (1910) and Donisthorpe (1927).

Between April 26 and May 3, 1930, nine trips were made to a group of four nests of *Lasius umbratus mixtus aphidicola* Walsh, near Windham, Ohio, to obtain and study the myremcocoles of this species. The ant colonies were established in beech logs in an advanced state of decay (stages 3.5 to 4 of the log decay cycle of Shelford, 1913, pp. 246–247). The wood was soft, easily crumbled and moist, often overgrown with moss and permeated with fungi and the tunnels of xylophagous beetles. The logs lay on the soft, leaf-moulded floor of a young climax forest of *Fagus grandifolia*, on the mesophytic east slope of Windham creek ravine.

The nests yielded two queens, workers and larvae of *Lasius aphidicola* Walsh, and a number of additional arthropods,

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[1]Contribution from the Zoological Laboratories of the University of Illinois, No. 417.

I am indebted to Mr. Thomas Park, University of Chicago, for the determination of the host ants used in this report; to Dr. T. H. Frison, Illinois State Natural History Survey, for determination of aphids; to Dr. H. E. Ewing, Department of Agriculture, for identification of acarinids; and to Dr. T. E. Snyder, Bureau of Entomology, and Dr. W. M. Mann, Smithsonian Institution, for criticism of the manuscript.

e. g., one section of a log nest was examined in detail and was found to harbor:

ANTS—
*Lasius umbratus mixtus aphidicola* Walsh..... 1 Queen
180 Workers
36 Larvae

APHIDS—
*Prociphilus* species..... 15 Apterous, viviparous females

BEETLES—
Colydiidae: *Philothermus glabriculus* Lec..... 1
Pselaphidae: *Ceophyllus monilis* Lec..... 15 (7♂♂; 8♀♀)
Clavigeridae: *Adranes lecontei* Brendel..... 35 (14♂♂; 21♀♀)

MITES—
Gamasoidea.....ca 40 juveniles upon the *Adranes* collected.

In the laboratory artificial nests were made of petri dishes holding earth and bits of wood. The nest temperature was held fairly constant (19° to 21° C.), the air kept near saturation by strips of moistened sponge, and the nests were in complete darkness except when under observation. Eight nests were thus established and maintained, the ants being fed on sugar syrup and strained, commercial honey. Observations were made on these nests or on isolated groups with the unaided eye, and at 10, 20, and 40 diameters magnification.

### BEHAVIOR OF *Lasius umbratus mixtus aphidicola*.

When installed in the laboratory nests, the host ants took up their normal course of activity after the first few minutes of characteristic aimless, rapid wandering in their new environment. The queens soon entered one of the first burrows excavated and were seen rarely thereafter. The workers began excavating nest tunnels, feeding on sugar syrup, regurgitating droplets of liquid to their sisters, carrying ant larvae from one part of the nest to another, carrying away debris and an occasional dead worker, and transporting aphids.

On one occasion (May 15, 1930, 9:20 P. M.) when feeding a colony, which had been starved for three days, on honey, five workers which were carrying larvae in their mandibles dropped their burdens summarily on approaching the food. All of these larvae fell into the honey. After the ants had ceased feeding, 25 minutes later, these workers each licked their respective larvae, picked them up, and carried them to a newly established larval pile.

Since the nests were kept in darkness, there was a tendency for the workers to pile their larvae in areas of the nests not covered by earth or wood. Consequently extended observation of these piles of larvae and the attending workers and beetles was not difficult when the nests were brought into the light.

BEHAVIOR OF *Gamasoidea* (*Parasitoidea*).

Almost every individual *Adranes lecontei* examined microscopically had several minute, juvenile (larval), six-legged mites upon it. These undetermined acarinids were found fiarmly appressed to the oily integument of the beetles. They occurred in a great variety of places. They were found especially upon the dorsal abdominal area near the trichomes, or on the lateral margins, and ventrally near the metathorax or lateral abdominal margins. They were taken less frequently on the thoracic sternites and legs. It is possible that they fed on the oils and dirt of the host's integument, or even on nest refuse, since these small mites were noted twice in the floor of the artificial nests. On May 12 one was observed, under a lens, to crawl from a particle of earth to the dorsal surface of the abdomen of an *Adranes*. It stayed in one spot on the beetle for three minutes, and then crawled down to the soil once more, to disappear between two bits of earth. It is possible, as suggested by Banks (1915), that such young mites are phoretic, being carried about from place to place on the host's surfaces. They were not found on the host ants, or other associates of the artificial *Lasius* colonies, but may easily occur upon the latter. One wonders if these are (1) single-hosted, being found as immature or adult mites, or both, upon *Adranes lecontei*, (2) double-hosted, with immature stages on *lecontei* and mature phase upon workers of *Lasius aphidicola*, or (3) if the mites exhibit no host preference but a marked phorecy?

Several mature, light brown mites (*Antennophorus wasmanni* Wheeler) were observed in the artificial nests. An *aphidicola* worker was seen carrying one of these acarinids. The mite was placed beneath the head and mouth-parts of the worker ant, its anterior end directed forward, with the posterior three pairs of legs clasping the head of the ant. The long, first pair of legs was stretched out, antennae-like, forward, between the antennae of the host after the manner described by Janet, Wheeler, Donisthorpe and others. The ant made irregularly

timed efforts to dislodge the mite apparently, pulling at it with its prothoracic tarsi, and occasionally shaking its head. These abortive movements continued for fifteen minutes, and then stopped. The ant paid no further attention to its burden, and subsequently entered a gallery, bearing the mite.

### Behavior of *Adranes lecontei*.

The clavigerid, *Adranes lecontei* Brendel, has been found associated with species of *Lasius* by a number of workers in North America, e. g., with *Lasius umbratus* (?) by H. G. Hubbard (Schwarz, 1890); with *Lasius minutus* Emery in the autumn and *Lasius aphidicola* Walsh in the spring (Wickham, 1894); with *Lasius mixtus* Nyl. (Smith, 1899); and *Lasius niger americanus* Emery (Blatchley, 1910). An earlier record of this blind beetle by Dury (Hamilton, 1888) may be attributed to *Lasius aphidicola* or one of the related forms.

It has been noted previously that practically nothing is known concerning the ecological relationships of *Adranes lecontei*, and it is hoped that the following observations may further our knowledge in this direction.

Some fifty of these clavigerids were obtained from the Windham nests of *Lasius aphidicola*, and observed in the laboratory. In the first place the writer was impressed by those "symphylic characteristics" which have been emphasized by many as belonging more or less wholly to many of the true guests of ants. These may be summed up for *Adranes lecontei* as follows: (1) the red color and peculiar oily surface of the integument; (2) the well-developed, oily, yellow trichomes or tufts of bristles; one large, usually twisted pair on the humeral angles of the first abdominal tergite, and a second pair on the middle of the apical elytral margins. The second pair usually is smaller, and has the bristles shorter, more straight, and often converged into a triangular mass of golden hair. The bristles of all the trichomes have their free, distal ends directed towards the middle of the abdomen, so that the two trichomes of either side of the beetle more or less approach one another. (3) The inconspicuous, oval mouth and the modified mouth-parts, clothed with golden pubescence, and quite obviously adjusted for biting and scraping. (4) The cylindrical, sparsely pubescent, two-segmented antennae, with the distal segment enlarged basally, elongated and slightly curved. (5) The rather deliberate,

slow, stiff walk, and (6) the habit of often twirling the antennae when approached by a host ant.

When the artificial nests were supplied with food, the beetles were not observed to feed upon the pools of sugar syrup or honey, even after starving one nest for six days. At the end of this time two *Lasius* workers and two *Adranes* were found dead in the nest. The ants were not eaten, but the beetles were badly mangled, the elytra and legs of one, only, remaining so that either the ants or the surviving beetles had fed upon the two dead *Adranes*.

At the end of this period of starvation the ants fed and regurgitated vigorously, but the clavigerids were not seen to

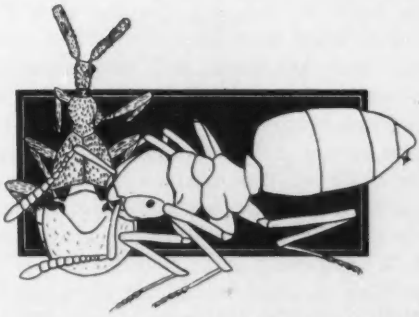

FIG. 1. A worker of the host ant, *Lasius aphidicola* Walsh, licking the trichomes of *Adranes lecontei* Brendel.

solicit food, nor to be fed by their hosts. Although the writer is of the opinion that the latter do regurgitate liquid food under proper stimulation to the *Adranes*, this specific act was not noted in the course of these observations. However, from accounts on the European relatives of this beetle, such an act was anticipated.

On the other hand, the worker ants frequently sucked and licked the trichomes of the *Adranes*, (Fig. 1). Such attentions were paid at all hours of the day and night when the colonies were observed, both when the beetles were quiet and when they were walking about in the nests. In the latter case, a beetle would stop, when approached by an ant, twirl its antennae, and often the ant would pause and lick the trichomes for as long as two minutes.

The most interesting behavior of the *Adranes* studied was that associated with their assiduous exploitation of the host's larvae. The beetles were active in the laboratory nests especially where worker ants had piled their larvae. Only rarely were the larvae unattended by both ants and beetles. It was not an infrequent occurrence to see all of the *Adranes* in one nest (as many as twelve beetles in some cases) gathered upon as many ant larvae.

The *Adranes* manifested two types of activity concerned with the ant larvae of their hosts. These phases apparently differed only in degree of intensity. One phase dealt with what appeared to be aimless or random wandering among the larvae. Individuals were continually arriving, to remain for from fifteen minutes to an hour in this stimulating area. During this time they walked back and forth over the assembled host larvae, moving their antennae and mouth-parts, and often halting momentarily to lower their heads and tap one of latter.

The second phase was concerned with the deliberate licking and biting of the larvae of *Lasius aphidicola*. Usually a single beetle would be observed mounted, but as many as four have been seen gathered about one larva, raking it with their tarsi, stroking it with their antennae, and licking and biting the soft surface. Such a gathering was reminiscent of the carabid synoekete, *Tachyura incurva*, on the larvae of the host *Formica ulkei*, (Park, 1929). In the latter case, however, the carabids were attacking dead or disabled prey, while the *Adranes* were noted only on living *Lasius* larvae, and their attentions in general were more those of a temporary ectoparasite.

Occasionally a larva would be distinctly bitten by an *Adranes*. After biting, the beetle would pull up its head rapidly, with a jerking motion. This act was observed three times, each time the bite being made on the anterior end of the larva. On one occasion, as the beetle was jerking up its head, a *Lasius* worker attending an adjacent larva, stopped its ministrations and paradoxically, licked the trichomes of the beetle. Usually the larvae were not treated so roughly by the beetles. The latter frequently embraced larvae with their legs, turned them first one way and then another, or rotated them on the larva's long axis. While the larva was being turned about, the *Adranes* methodically licked the larval integument.

The males of *Adranes lecontei* are especially fitted for this method of attack, which was studied under the binocular at forty diameters magnification. The posterior, basal portion of each mesothoracic femur is produced into a broad, thin, pointed spine. This sex-differentiating character, since it is absent in the female, is of interest here from another point of view. The mesofemoral spines, originally assigned by Brendel to the trochanter (1865, 1890) but since then correctly noted by Schwarz (1896), and figured and described by Wickham (1901), may give the males an advantage over the females in holding and obtaining food from the *Lasius* larvae. When a

FIG. 2. A male *Adranes lecontei* Brendel clasping a larva of its host, *Lasius aphidicola* Walsh, and licking its anterior segments. Note the meso-femoral spines pressing upon the larval integument.

male embraced a larva, these spines were frequently at right angles to the latter and directed towards the larva's soft body, (Fig. 2). Thus the spines may aid in holding the beetle in position, and by their constant scratching have considerable abrasive action. The spines are applied with sufficient force to press in the hypodermis of the larva, and it is possible that they pierce the latter at intervals. If this is so we have a minute mechanism for increasing the amount of liquids on the larval surface. The beetles, then, would appear to feed on the host larvae, at least in part, this food being composed of integumental exudates, oils, excretions, and possibly body fluid. These are gathered efficiently by the mouth-parts, through the combing action of the relatively long, golden setae

of the latter, and the oval, dish-like oral aperture. I have seen the mouth applied to one spot of a larva's integument for as long as three minutes, the mandibles and palpi working rapidly, all of the time.

In addition to having their trichomes licked by the host *Lasius*, and obtaining food at the expense of the latter's larvae, the *Adranes lecontei*, both males and females, were transported by the ants in the laboratory nests. This act has been observed frequently in the related European *Claviger testaceus*, where the latter rides about upon the backs of the workers or queens of

FIG. 3. An *Adranes lecontei* Brendel being carried about the artificial nest on the gaster of a host worker of *Lasius aphidicola* Walsh.

various species of *Lasius* (Crawley, 1916; Donisthorpe, 1927, p. 14). Since the *Adranes* were not seen licking or scraping the host ants while being carried about, their behavior may be assigned provisionally as a form of phorecy. Occasionally their transportation was accidental, e. g., while a clavigerid would be embracing and licking an ant larva, the latter would be picked up by a worker ant and both larva and beetle carried from one portion of the nest to another.

When being carried, the beetles would cling tightly to the gaster of their host, embracing it as they did the ant larvae. Thus beetles were found clinging to the apex of the gaster by their middle legs, or on the dorsal portion of the host's abdomen (Fig. 3). In one instance, a clavigerid was carried about for

ninety minutes. During this period the ant made several efforts to get rid of the beetle, and was finally successful. The ant then walked off, but the *Adranes* fell to the earth. It lay upon its side, perfectly quiet and rigid, as though paralysed or letisimulating for one minute, and then slowly resumed its normal activity.

### Behavior of *Ceophyllus monilis.*

Some twenty *Ceophyllus monilis* Lec. were taken from the Windham nests. These pselaphids were found to be unmolested by the host ants, the latter passing around or over them with at most a momentary pause or investigatory movements of the antennae. On the other hand, the beetles were not observed to be fed by the ants, nor were the latter seen to lick, or attend them in any way. When an ant approached a pselaphid, the latter either vibrated its antennae on or in front of the host, or apparently was not stimulated at all. This twirling of the antennae has been noted for a scydmaenid synoekete, *Euthia plicata* Gyll., by Donisthorpe (1927, p. 40) among others.

Since both *Ceophyllus monilis* and *Adranes lecontei* have been taken together from the same nests of *Lasius aphidicola* in Iowa by Wickham (1894), their occurrence with this host may be more constant, and ecologically significant than is at first apparent.

*Ceophyllus* was found frequently on the larval piles with *Adranes*. However, the larvae apparently did not stimulate the former to the great extent noted previously for *Adranes*. Although individuals were frequently observed walking among or over the accumulated larvae, and occasionally licking one of them, or raking it with their tarsi, their actions were neither so methodical nor assiduous as those of the clavigerids.

In this respect, however, it is interesting to mention that the prothoracic femora of *Ceophyllus monilis* are armed with three spines in both sexes. These spines are acute and set at such an angle that they would serve as formidable piercing weapons, especially against the integument of an ant larva when the latter is encircled by these legs. Under such conditions, the tibia of a leg would be pressing upwards from beneath, and aiding the operation of the spined femur from above. Such an embrace was repeatedly seen in *Adranes lecontei*, and may occur in

*Ceophyllus*. This means of prehension is to some degree analogous to the use of the raptorial legs by certain mantids (Fabre, 1925), and the prehensile front legs of the Oriental phymatid, *Carcinocoris*, (Imms, 1924, p. 349).

Although *Ceophyllus* was not seen to use the femoral spines of the fore legs in this manner, the possibility remains that these spines may be employed in such a way, at least occasion-

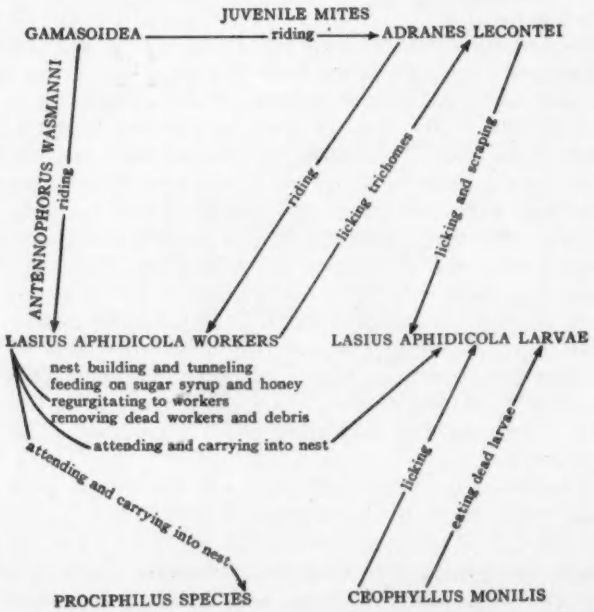


FIG. 4. Diagram of some of the interrelations existing within the *Lasius aphidicola* biocoenose under laboratory conditions.

ally or even accidentally. Such a possibility is strengthened by the behavior noted in *Adranes*. It is even possible that this usage of spines is more general than would be supposed among the many pselaphoids which are found in the nests of ants. In Pselaphidae spines may be peculiar to one sex, or found equally well developed in both sexes, as in *Ceophyllus monilis*, *Cedius ziegleri* and *C. spinosus*. In number, segment of leg, and degree of specialization, they are also quite diverse.

In addition to any sexual significance which may or may not be involved, are such structural modifications of value in other ecological adjustments in the life-history of certain species, e. g., *Adranes lecontei?* Wasmann (1911) thought that morphological differences among varieties of *Atemeles paradoxus* Grav. to be specific adjustments to certain forms of its summer host (*Formica*). Careful research under controlled conditions, however, is indicated before an opinion may be reached on this point.

That *Ceophyllus monilis* is tolerated by *Lasius aphidicola* is certainly shown. Further, that it feeds in part upon the latter's larvae is also clear from the following observation. On May 15, one of these pselaphids was seen (under a lens) to emerge between two nest particles, carrying an ant larva between its mandibles. It walked slowly ahead, chewing vigorously upon the latter. This continued until the larva was practically entirely consumed save for mere shreds of integument. The larva was dead when first noted, mangled, and slightly discolored so that the beetle had either been feeding upon it for some time, or had found it dead in the nest.

The several forms of behavior listed in this report are represented in chart form in Figure 4, in an attempt to give a further insight into the ecological interrelations of the *Lasius aphidicola* biocoenose.

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## BOOK NOTICE.

THE BUTTERFLY BOOK (NEW AND THOROUGHLY REVISED EDITION), A POPULAR AND SCIENTIFIC MANUAL, DESCRIBING AND DEPICTING ALL THE BUTTERFLIES OF THE UNITED STATES AND CANADA, by W. J. HOLLAND, pp. I-XII, and 1–424, with 198 text figures, 77 plates (73 colored) with 1,855 plate figures. Published by Doubleday, Doran and Company, Inc., Garden City, New York.

This is a thoroughly revised edition of the Butterfly Book which has been the ready reference book on American butterflies since it appeared in 1898. The revision has added 30 pages and 29 plates to the original volume. The plates are grouped at the back where they are more convenient than when interleaved as in the earlier volume. To the writer the original Butterfly Book, with its wealth of beautiful illustrations, was one of the high points in his introduction to the wonders of entomology. He has found it to have the same effect on his students. In fact the less well trained summer school students have had to be watched that they did not forget to return Department copies.

The Butterfly Book is a classic because it is the first successful effort to cover an order of North American insects from coast to coast with illustrations of every species. This has been accomplished in many groups of European insects, but there the fauna was exterminated by the ice catching the fauna and flora against the east and west ranges of the Pyrenees, Alps and Carpathians. In North America, with mountains running north and south the fauna survived the ice age by temporarily moving southward. Our genera are complete as originally evolved with many close species and from five to ten times as many species as in the same groups in Europe. The dream of the American systematist is of the day when we will have a completely illustrated volume covering all species in each of the other groups. Doctor Holland is the pioneer in this great undertaking.

—C. H. K.

# AN INQUIRY INTO THE STABILITY AND RESTRICTION OF FEEDING HABITS OF CERTAIN CACTUS INSECTS.

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Notwithstanding the far-reaching importance of the host affinities of plant-feeding insects and the large volume of available data on host relations of particular insect pests, little attention has been devoted to the general aspects of host restriction. This condition is the more remarkable because virtually all problems in applied agricultural entomology are vitally affected by the degree of restriction of feeding habits exhibited by economic species.

The importance of host restriction is perhaps nowhere greater than in projects involving the introduction of plant-feeding insects for the biological control of plant pests. Indeed, host restriction here becomes the paramount consideration in as much as the varied agricultural interests of the importing country must be safeguarded against the possibility of the introduced species attacking economic vegetation. Therefore, in connection with the importation of American cactus-feeding insects into Australia for the purpose of combating species of Opuntia there naturalized, the authorities deemed it essential to determine the stability of their feeding habits prior to liberation in the new country, notwithstanding that these species had been selected for introduction on the basis of general evidence which clearly indicated them to be distinctly cactus-feeding species in America.

The results of the experimental work performed with this objective, together with the supplementary lines of data employed in determining the host restriction of these insects, are presented as a contribution to this fundamental aspect of entomology.

[1]Acknowledgments are due to the Professors of the Department of Zoology and Entomology, and of Botany, Ohio State University, and particularly to Professor Herbert Osborn, under whose general supervision this work has been produced. The writer is also indebted to the late Doctor W. D. Hunter for helpful suggestions, and to Mr. E. Mortensen for assistance in recording the experimental results. These data, secured while in the capacity of Officer-in-Charge, Prickly-pear Investigations, are published with the permission of the Commonwealth (of Australia) Prickly-pear Board.

## TYPES OF FEEDING HABITS.

The feeding habits of phytophagous insects show the greatest diversity, some species being practically omnivorous and others exhibiting rather definite limitations. On the basis of these differences Brues (*3*)[2] has followed Reuter's designation of polyphagous and monophagous species and has added the oligophagous category which, however, embraces two distinct groups. We may therefore classify the food habits of phytophagous insects broadly as follows: (1) Polyphagous species, possessed of indiscriminate feeding habits. (2) Oligophagous species, those subsisting upon several unrelated plants. (3) Strict oligophagous species, feeding upon several related plants. (4) Monophagous species, living upon a single plant species.

Some of these categories are susceptible of further subdivision. Thus, in the oligophagous class we find groups of insects in which periodic feeding upon widely different plant species has become the established order. This alternation of hosts is sometimes an ontogenetic and sometimes a seasonal phenomenon. However, at the present writing, due to our yet incomplete knowledge of hosts normally fed upon by the majority of phytophagous insects it seems inadvisable to attempt a more exact classification of food habits.

## SCOPE OF INVESTIGATION.

In the experimental work eight cactus insects, including five hemipterous, two lepidopterous, and one coleopterous species, have been tested under cage conditions on thirty-five or fewer species of economic plants. Supplementary to the cage tests of feeding stability, several naturally-laid-out field experiments were employed to secure exact data relative to the feeding restriction obtaining in nature. In addition, other evidence indicative of the degree of host restriction has been sought in records, observations, and in conditions peculiar to the insects or to the Cactaceae or to the relationships between plants and insects.

The insects with their systematic positions are listed as follows:

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[2]Italic numbers in parentheses refer to literature cited.

THE ORDERS AND FAMILIES OF CACTUS INSECTS

HEMIPTERA-HETEROPTERA:
1. *Chelinidea vittiger* subsp. *aequoris* McAtee.....Family Coreidae
2. *Chelinidea tabulata* (Burmeister).....Family Coreidae
3. *Chelinidea canyona* Hamlin.....Family Coreidae
4. *Narnia pallidicornis* Stal.....Family Coreidae

HEMIPTERA-HOMOPTERA:
5. *Dactylopius tomentosus* (Lamarck).....Family Coccidae

LEPIDOPTERA:
6. *Olyca junctolineella* (Hulst).....Family Pyralidae
7. *Mimorista flavidissimalis* Grote.....Family Pyralidae

COLEOPTERA:
8. *Moneilema crassa* Le Conte.....Family Cerambycidae

The comprehensive knowledge of the above species necessary to initiating and conducting this investigation was gained through field and laboratory study of their life histories and habits throughout the cactus regions of North America and also in Australia from 1920 to 1923. Biological data on all the above species, except *Narnia pallidicornis*, have previously been published (*7*, *8*, *9*).

The thirty-five economic plants tested include the more important field, truck, and fruit crops. According to Bailey (*1*), they represent 34 species belonging to 16 families. Their botanical relationships are shown in the following list:

ECONOMIC PLANTS TESTED AS POSSIBLE HOSTS OF CACTUS INSECTS.

| | | |
|---|---|---|
| Sorghum | *Holcus sorghum*, L. | Gramineae |
| Sudan grass | *Holcus sudanensis*, Bailey | Gramineae |
| Millet | *Panicum miliaceum*, L. | Gramineae |
| Oat | *Avena sativa*, L. | Gramineae |
| Corn | *Zea mays*, L. | Gramineae |
| Asparagus | *Asparagus officinalis*, L. var. *altilis*, L. | Liliaceae |
| Onion | *Allium cepa*, L. | Liliaceae |
| Agave | *Agave* sp. | Amaryllidaceae |
| Beet | *Beta vulgaris*, L. | Chenopodiaceae |
| Turnip | *Brassica napus*, L. | Cruciferae |
| Cabbage | *Brassica oleracea*, L. var. *capitata*, L. | Cruciferae |
| Pea | *Pisum sativum*, L. | Leguminosae |
| Bean | *Phaseolus vulgaris*, L. | Leguminosae |
| Peanut | *Arachis hypogaea*, L. | Leguminosae |
| Alfalfa | *Medicago sativa*, L. | Leguminosae |
| Clover | *Trifolium* sp. | Leguminosae |
| Cotton | *Gossypium hirsutum*, L. | Malvaceae |
| Carrot | *Daucus carota*, L. var. *sativa*, DC | Umbelliferae |
| Sweet potato | *Ipomea batatae*, Lam. | Convolvulaceae |
| Potato | *Solanum tuberosum*, L. | Solanaceae |
| Eggplant | *Solanum melongena*, L. | Solanaceae |
| Tomato | *Lycopersicon esculentum*, Mill. | Solanaceae |
| Tobacco | *Nicotiana tabacum*, L. | Solanaceae |
| Pumpkin | *Cucurbita pepo*, L. | Cucurbitaceae |
| Squash | *Cucurbita pepo*, L. var. *condensa*, Bailey | Cucurbitaceae |
| Cucumber | *Cucumeris sativus*, L. | Cucurbitaceae |

| | | |
|---|---|---|
| Cantaloupe | *Cucumeris melo*, L. var. *cantalupensis*, Naud | Cucurbitaceae |
| Watermelon | *Citrullus vulgaris*, Schrad | Cucurbitaceae |
| Lettuce | *Lactuca sativa*, L | Compositae |
| Pecan | *Carya pecan*, A. & G | Juglandaceae |
| Fig | *Ficus carica*, L | Moraceae |
| Peach | *Prunus persica*, Sieb. & Zucc | Rosaceae |
| Plum | *Prunus* sp | Rosaceae |
| Apple | *Pyrus malus*, L | Rosaceae |
| Grape | *Vitis labruscana*, Bailey | Vitaceae |

Hereafter these plants are termed economic plants in contradistinction to cactus, according to the Australian view. This distinction is, however, contrary to the economic status of cactus in America, for in the southwestern United States many species constitute an immense and valuable forage reservoir, while in Mexico other species are valued for their fruits.

The experimental work here recorded was conducted during the summer and fall of 1923 at Uvalde, Texas.

## INVESTIGATION OF STABILITY OF FEEDING HABITS.

### EXPERIMENTAL METHODS.

Because of conceivable differences in the stability of feeding habits of newly-hatched larvae or nymphs as compared with more mature individuals, two series of tests were devised. The first series was planned to indicate the ability of adults reared upon cactus to change to a diet of some economic plant; the second series, in which eggs were used, was designed to reveal the adaptability to economic plants of individuals which had not previously fed upon cactus.

The first series of tests was conducted in wire cages under outdoor conditions in a plot laid out as shown in Figure 1. For each species of insect tested on each economic plant there were four cages, the contents of which may be noted in Figure 2. In this arrangement each experiment actually represents a double test with controls. Thus the economic plant in cage 1, being free from the insect, provided a basis of comparison with a similar plant in cage 2 exposed to a given insect species acting under the stress of starvation. Cage 3 constituted a preferential test to show the relative activities of the insect on the economic plant and cactus, the result of which would be employed in deciding the extent to which feeding in cage 2, if any, was due to the starvation factor. Cage 4 established a norm for the activities of the insect on its natural host under

cage conditions. One cage 4 frequently served for several tests. The tests on trees consisted of only two cages, representing cages 2 and 4 of the plot tests.

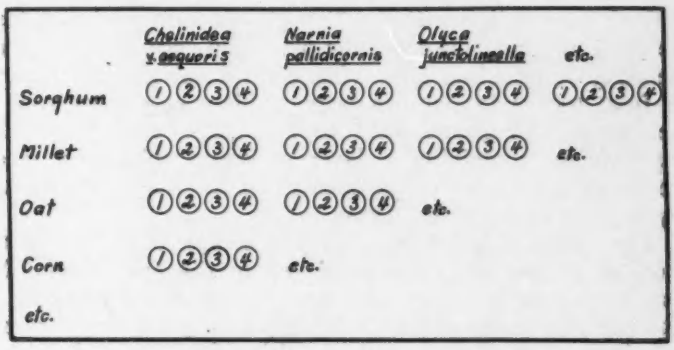


FIG. 1. Showing layout of plot experiments.

Twenty individuals of each insect species, save in the few exceptional instances cited later, were placed in each of cages 2, 3 and 4 of each test. In all instances these individuals had developed on cactus.

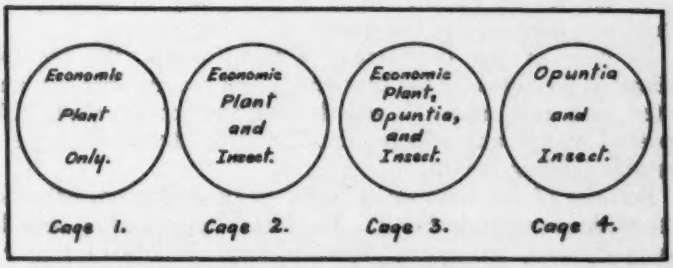


FIG. 2. Showing content of the four cages in the test of each species of insect on each species of economic plant.

In the second series of experiments, due to the ability of newly-hatched individuals to escape through the meshes of such cages as were employed in the first series and because of the impracticability of making daily observations when using such cages lined with cheesecloth, it was necessary to conduct

these tests in large-mouth drinking glasses. Young plants or cuttings were planted in one inch of moist sand in these glasses and the tops covered with cheese cloth. When so placed the plants remained turgid for considerable periods, being replaced by fresh ones as they wilted. Two glasses comprised each test, the one containing the economic plant and eggs, and the other enclosing Opuntia and eggs. One control was allowed to serve for from twelve to eighteen tests. Thirty eggs were used in each glass. All glasses were kept in large, shallow wooden trays which, containing a layer of damp sphagnum moss, prevented desiccation of the plants and the insects during the dry summer of southwest Texas.

The second series of tests was not completed by the writer upon all of the 35 plants employed in the first series. No tests have been included save those in which the hatching of eggs was practically perfect. All eggs in a given test were not deposited on the same date, resulting in uneven hatching. Hence, the period of survival of the nymphs cannot be employed in indicating any influence of the economic plants upon them. Although separately conducted, the results of the two series of tests are presented together under each species of insect.

Throughout all tests *Opuntia lindheimeri* Engelm., the dominant prickly-pear of southwest Texas and the species on which all of the insects breed satisfactorily in nature, was constantly used in cages or glasses requiring cactus.

In view of the two series of experiments, the two-fold indication provided by the first series, and the number of plants tested with each insect, it was decided that no tests would be repeated except any which should provide strong evidence of unstable feeding habits.

Because of the number of cages to be examined, extended observations were prevented. The instances of feeding actually observed, then, necessarily represent such activities for only a very brief portion of the period covered by the various tests. It was felt, however, that such records, taken collectively, would provide a fair indication of insect activities in each cage. Data of this nature were, of course, supplemented by noting the condition of the economic plants as well as the longevity or development of the insects. For economy of space the tabulations of results have been omitted.

**Chelinidea vittiger** subsp. **aequoris** McAtee.

Uhler's *Chelinidea vittiger* is a wide-spread species, occurring in California and the Rocky Mountain States and ranging eastward to Virginia and Florida. *C. v. aequoris*, the subspecies occurring from Texas eastward, is the form which was tested. This subspecies commonly feeds upon many species of Opuntia and has also been found on species of *Echinocereus*. The adults hibernate in rubbish at the bases of cactus plants. The first eggs of the season are deposited in March, there being four to five broods annually. All stages are associated with cactus, the eggs being deposited on the spines and the nymphs as well as the adults feeding on cactus. Feeding occurs chiefly on the more distal joints, but also to some extent on the fruits and older joints.

EXPERIMENTS WITH ADULTS.

Under the stress of starvation in cages 2, *Chelinidea v. aequoris* attempted to feed upon 20 of the 35 plants and upon a volunteer ragweed plant.[3] The majority of these instances were in the nature of trial feeding, which was not continued, was not beneficial to the insects, and was non-injurious to the plants. Mating on several economic plants was observed and oviposition occurred on five plants, all of which had been subjected to feeding attempts. The chief interest in this subseries attaches to the feeding which obtained on pea and ragweed, peach, fig, pecan, sudan grass, potato, cotton and agave. On the last four of these plants, although very few or no instances of feeding were observed, discolored spots indicated numerous instances of trial feeding. The feeding which occurred on pea and ragweed, peach, fig, and pecan was clearly differentiated from that on other plants.

Feeding occurred on the pea plant during the first week, at the end of which time all pods and several leaves had been sucked dry; thereafter the feeding was confined to a ragweed plant which had come up inside the cage. The extreme longevity[4] in this cage of 24 days against the average of 14 days in all other cages during the same period indicates some

[3] *Ambrosia artemisiaefolia* L., family Compositae.

[4] Extreme longevity, referring to the interval from the beginning of an experiment until the last cactus insect died, is used in comparing survival in different cages and on different economic plants.

benefit from the feeding upon the two plants. The ragweed plant showed no injury from this feeding.

The 21 observed instances of feeding in the peach cage were distributed thus: fruit, 11; leaf petiole, 5; twig, 5. This feeding was undoubtedly beneficial to the insects since the extreme longevity was 63 days, whereas, in other cages operating during the same period, the average was 14 days. Despite the numerous instances of feeding noted and the long period of survival of the insects, no injury to the various parts of the plant was apparent.

On fig, except for two cases involving the leaves, all of the observed feeding was on the fruit. The extreme longevity of 74 days as compared with the average of 14 days on other economic plants reflects unquestioned benefit from this feeding. Slight injury to both fruit and foliage was noticeable.

Half of the ten observed instances of feeding on pecan related to the husks of green nuts while the remainder occurred on the leaves. Extreme longevity of 19 days in this cage against an average of 12 days in other cages operating simultaneously, renders doubtful any benefit from feeding. No injury resulted from this feeding.

In cages 3, with both cactus and an economic plant available, no feeding or feeding marks on the economic plants were observed, and oviposition on these plants occurred in only two instances, one being on pea. Otherwise the reactions of the insects in cages 3 closely paralleled those in cages 4 where only cactus was available.

### EXPERIMENTS WITH FIRST STAGE NYMPHS.

The complete series of economic plants, excepting carrot, turnip, onion, eggplant, potato, agave, tobacco, and apple, were used in experiments with nymphs of this insect. Feeding attempts were observed on lettuce and plum. One leaf of the former was very slightly injured by this feeding, but no injury to the plum twig resulted. On none of the plants did the insects develop beyond the first nymphal stage.

Two controls were conducted with these tests. In both the nymphs prospered during early life but there was considerable mortality during their later development. Ten individuals had reached the fourth nymphal stage in the one, and 17 in the other control when they were discontinued.

**Chelinidea tabulata** (Burmeister).

*Chelinidea tabulata* is a Mexican species which ranges northward to Austin, Texas. In Texas it is the dominant form of Chelinidea only in the lower Rio Grande Valley, where five broods are produced during the season. Its life history and habits are very similar to those of the preceding species. It has been taken on a large number of species of Opuntia.

EXPERIMENTS WITH ADULTS.

No apparent injury to any economic plant was caused by *Chelinidea tabulata* in cages (numbered 2) providing only the economic plants, although feeding marks were noted on millet and cotton. In these instances, however, the extreme longevity of the insects was but slightly greater than the average on other plants during the same period, being 12 and 14 days, respectively, against the average of 10 days. On cotton one insect was observed to remove its proboscis from the plant and to reinsert it in another place; another individual was found dead, suspended by its inserted proboscis.

Insects were observed with beaks inserted in 10 of the 35 economic plants, half of these observations attaching to the tree tests where the insects, however, showed no increase in longevity. Despite the number of instances of feeding on fig fruits no injury to them was discernible.

Eggs were deposited in cages 2 upon 18 of the economic plants, seven of which were also fed upon, indicating that the ovipositional habits of this species are more flexible than are those of its congeners.

In cages 3, notwithstanding the availability of Opuntia, the deposition of eggs on 11 economic plants, or in approximately one-third of the tests, supports the above conclusion that the requirements for activating the oviposition response are less stringent than in the case of the other two Chelinideas treated. Incidentally, 7 of these same plants also had eggs laid on them in cages 2. Otherwise, normal reactions to cactus, as compared with cages 4, occurred in cages 3.

EXPERIMENTS WITH FIRST STAGE NYMPHS.

Tests of first stage nymphs were completed on asparagus, tomato, pea, sorghum, lettuce, bean, beet, Sudan grass, alfalfa,

clover, cabbage, onion, eggplant, peanut, tobacco, peach and pecan. Trial feeding was observed on cabbage and onion, that on the former being entirely negligible. On onion three nymphs were dead, with their probosces inserted in the plant. Development in no instance proceeded beyond the first nymphal stage.

In the single control experiment the nymphs prospered during the first and second stages but gradually decreased in number. Only four individuals reached the fourth nymphal stage, and three of these produced adults. This does not affect the validity of the control lot, since the survival here was still high after all nymphs had died in the tests.

**Chelinidea canyona** Hamlin.

This species is of restricted range, being known only from western Texas. It has been found feeding on several species of Opuntia and to a lesser extent upon an *Echinocereus*, probably *enneacanthus* Engelm. In the canyon country north of Uvalde, Texas, it has only three generations during the season. Otherwise its life history and habits are very like those of its congeners.

EXPERIMENTS WITH ADULTS.

When confined with economic plants alone (cages 2) *Chelinidea canyona* was observed attempting to feed upon 16 of the 35, and on a volunteer ragweed[5] in the corn cage. In the majority of these instances the feeding was merely the insertion of beaks in the strange plants and did not result in benefit to the insects nor injury to the plants. The feeding on pea, agave and fig was of a different nature, however, and requires comment.

The feeding on pea was plainly injurious to the pods, but less extensive than that of *C. v. aequoris* on pea, and was not beneficial to the insects. Indeed, this feeding even appears to have been disadvantageous, because the extreme longevity here was only five days as compared with the average of eight days on all other plants during this period.

Only three insects with beaks inserted in agave were observed, but the yellowish spots which developed on the plant

[5] *Ambrosia artemisiaefolia* L.

showed a greater extent of attempted feeding. No injury to the plant was apparent. This feeding also appears to have been detrimental to the insects for, whereas the extreme longevity on agave was only 15 days, it averaged 23 days during the same period in other cages, all of which showed less feeding tendency.

The feeding upon fig, almost entirely restricted to the fruits and producing slight injury on them, was doubtless of some benefit to the insects as their extreme longevity of 22 days was twice the average (11 days) in other current cages.

Other activities in cages 2 included only oviposition on 10 economic plants, which were different from the ones showing the greatest extent of feeding.

Few activities were observed on the economic plants in cages 3 with cactus also present. One insect was seen attempting to insert its proboscis in the cantaloupe plant. Eggs were laid on millet and oat, upon neither of which was any feeding observed in cages 2. Oviposition on oat occurred in both cages 2 and 3. With the exception of these minor defections from the habits of the species the insects gave their attention to cactus, upon which their activities were comparable to reactions observed in cages 4.

No tests with the nymphs of this species were made.

### **Narnia pallidicornis** Stal.

This species has a wide range, the writer having taken it throughout the cactus country of Texas, in southern California, on the west coast of Mexico and on the Mexican tableland as far south as Mexico City. The species overwinters as adults, and there are four broods during the summer. All stages are associated with cactus; the eggs usually being laid on the spines but also occasionally on the flat surfaces of the joints, while the nymphs and adults feed on the cactus fruits or tunas and to a lesser extent on the joints. Many species of Opuntia and several species of *Echinocereus* have been observed as the hosts of this species.

#### EXPERIMENTS WITH ADULTS.

Observations on cages 2 revealed adults of this species with probosces inserted in 11 of the 35 economic plants. None of the plants showed the slightest injury.

Oviposition occurred on 10 economic plants, only two of which had been subjected to trial feeding. The oviposition on cotton was especially abundant, the number of eggs deposited thereon being estimated at 200. During the hatching of these eggs one first stage nymph was observed with its beak inserted in a leaf petiole. All nymphs emigrated from the cage before attaining the second stage.

In cages 3, oviposition occurred upon seven economic plants which, for the most part, had been ignored as food in cages 2. Aside from these instances of egg-laying on the strange plants the reactions to cactus in these cages presented a general coincidence with the activities of the species in cages 4.

EXPERIMENTS WITH FIRST STAGE NYMPHS.

Several instances of attempted feeding were observed on lettuce, millet, and cotton, while single instances were also encountered on cucumber and plum. In no case was any injury discernible. In all these tests some of the nymphs reached the second stage and, on tomato, a few attained the third stage, although no feeding marks were observed on this plant. The moulting to the second stage common to this subseries of tests is intelligible in the light of the very brief duration of the first stage which, for this insect in these tests averaged about three days. Twenty-seven of the 35 economic plants were tested, the omissions including carrot, onion, eggplant, potato, cantaloupe, pumpkin, agave, and tobacco.

One of the controls for these tests contained 15 third stage nymphs at the time it was discontinued. In the other control the nymphs gradually died after the second stage, but several had reached the fourth stage when it was dismantled.

**Dactylopius tomentosus** (Lamarck).

*Dactylopius tomentosus* is a member of the homopterous family, Coccidae. The individuals found on cactus beneath the masses of pure white wax are all females, the winged males being of no importance as regards injury to the plant. Mature females produce very large numbers of living young, or "crawlers," which are dispersed by the wind. These crawlers quickly begin feeding and thereafter are unable to move to another location. During the summer this species shows

marked preference for the fruits and younger joints, while the last brood in the fall settles upon subterranean parts of the plant or on the lower surface of prostrate joints and develops slowly during the winter. Many broods are produced during the year. From the above we see that the species is constantly associated with cactus except for a very brief interval during the first nymphal stage.

Three distinct physiological strains, feeding on Opuntias and showing no morphological differences, were encountered in the United States by the writer. The Texas strain is widely distributed in that state on several Opuntias of which *Opuntia lindheimeri* Engelm., the preferred species, was used in these experiments.

Since the species is viviparous, and free-living only in the crawler stage, only one series of tests could be made. These were conducted after the plan of the first series except that the wire cages were lined with cheesecloth and daily observations were not made. The cages were examined at intervals of a week or ten days until all cultures had produced crawlers and satisfactory young cultures were established on the Opuntia in cages 3 and 4, which in no case required more than three weeks.

After the selection of mature, parasite-free cultures of this insect, the Opuntia joint was pared away until barely enough remained as a physical support for the attached females. Such reduction of available food, discovered in rearing the species, accelerates the production of crawlers by mature females. These tiny pieces of cactus rapidly dried out, and were not available as food for the succeeding brood of crawlers. A piece of Opuntia so prepared, and bearing females sufficient to produce 1000 or more crawlers, was placed in each of cages 2, 3 and 4 of the plot tests and in cages 2 and 4 of those on trees. In cages 3 it was so placed as to provide equal opportunity for the crawlers to reach the economic plant and the Opuntia.

This insect was tested on each of the 35 economic plants, with similar results in all tests. In each instance young cultures of varying extent developed upon Opuntia in cages 3 and 4, while no crawlers established themselves upon the economic plants in cages 2 or 3.

**Olyca junctolineella** (Hulst).

This member of the lepidopterous pyralid family is widely distributed throughout the main cactus area of North America, the writer having collected it at many Texas localities and in Mexico as far south as Cuernavaca, State of Morelos. In southern Texas the species produces two generations yearly, the large sluggish moths issuing in May and June and again in August through September. The eggs are deposited in a characteristic "egg-stick" composed of many disk-like eggs placed one upon another; these sticks are attached to cactus spines near the tips. The larvae, some two inches in length and one-quarter inch in diameter when grown, live solitarily within swellings of cactus joints. Pupation occurs in or on the ground near the plants fed upon as larvae. The imaginal life is brief, and the species thus exists in the larval stage throughout the year except for about two months occupied by the two pupal periods. All stages, except the pupa, are thus closely associated with cactus. This insect has been found feeding only in species of Opuntia, *O. lindheimeri* Engelm. and *O. engelmannii* Salm-Dyck apparently being favored species.

EXPERIMENTS WITH LARGE LARVAE.

The first series of experiments was conducted with larvae one-half to two-thirds grown. Twenty-seven of the 35 plants were tested, those omitted being lettuce, carrot, turnip, egg-plant, cantaloupe, pumpkin and tobacco. In cages 2, in the absence of cactus, the longevity of the larvae was brief, ranging from one to eight days. Attempts at feeding occurred on seven economic plants. The trial feeding on leaves of beet, peanut, and agave was very slight and all the larvae died within two, three and six days, respectively. Attempts to enter the stalk of corn were prevented by the hard exterior and all larvae in this cage succumbed within eight days. In the test on cabbage, one larva tunnelled through the head of cabbage, but all were dead in two days. Slight feeding also occurred within the stems of squash, but all larvae in this cage succumbed within seven days. Although several larvae entered a nearly ripe watermelon none of them survived at the end of four days. These instances of feeding on strange plants may all be regarded as trial feeding since little or no benefit to the insects resulted.

In the preferential tests provided by cages 3, feeding occurred on sorghum and cabbage. The top of the sorghum stalk had been cut off to fit the cage and the cabbage head was one placed in the cage with a small plant. In each instance two larvae entered at the point where the plants had been cut. After considerable tunnelling the larvae left the strange plants and entered the nearby Opuntia. Thus, in both cages 2 and 3, trial feeding occurred on the heads of cabbage, but was of very brief duration and reflected no benefit. Otherwise the activities of the larvae in cages 3 approximated the actions in cages 4 where all larvae reestablished themselves within cactus joints.

#### EXPERIMENTS WITH FIRST STAGE LARVAE.

In the second series of tests, performed only on fig, pecan, plum, grape and apple, the young larvae died within two to four days after hatching. Although they crawled freely over the plants no feeding attempts could be observed. In two controls the larvae entered the Opuntia and lived normally.

### **Mimorista flavidissimalis** Grote.

*Mimorista flavidissimalis* is a lepidopterous insect of the family Pyralidae. Although recorded (*10*) from Tucson, Arizona, it is a common species only in southern Texas and adjacent areas of Mexico. In midsummer the life cycle is completed in four weeks and, at Brownsville, Texas, there are as many as eight broods annually. The eggs are laid on the surfaces of the young Opuntia joints, whereon the larvae feed externally and later pupate. This species has been found only on platyopuntias. Within this group, however, it lives on many species, always confining its attack to the young, tender growth. All stages are thus closely associated with cactus.

#### EXPERIMENTS WITH LARGE LARVAE.

The first series of tests, employing larvae approximately half grown, was conducted on the entire series of 35 economic plants. In all tests the larvae died in cages 2 in the absence of cactus in five days or less. Very slight feeding occurred on the foliage of beet and potato, but was entirely negligible, the larvae dying within five and three days, respectively. In cages 3 the economic plants were entirely ignored whereas their behavior

on the young Opuntia joints was normal as compared to those in cages 4 where only cactus was available.

EXPERIMENTS WITH FIRST STAGE LARVAE.

Tests of the second series were made with 33 of the economic plants, carrot and potato having been omitted. No feeding whatever occurred in these experiments, the larvae dying within a few days after hatching although they freely crawled over the economic plants.

**Moneilema crassa** Le Conte.

This cerambycid beetle is common, though rarely abundant, in southwest Texas. The eggs are laid on the plant where it makes contact with the earth. The larvae feed internally in the roots or other portions of cactus plants touching the ground, while the adults feed upon the aerial parts of the plant. The species overwinters in the larval stage, producing adults in April and May. The latter give rise to the summer generation which attains the imaginal state in September. There are thus two generations annually, the species existing as larvae during most of the year. Many species of Opuntia and a few species of *Echinocereus* have been found as the only host plants in nature.

EXPERIMENTS WITH ADULTS.

Tests of 31 economic plants with adults comprised the first experimental series. Lettuce, carrot, eggplant, and tobacco were not tested. Ten adults were used in each cage. In cages 2, in the absence of cactus, the adults indulged in trial feeding on 17 plants. The chewing of leaves of pea, bean, beet, Sudan grass, onion, cotton, corn, sweet potato, pumpkin and watermelon caused very slight injury. On these plants the extreme longevity ranged from 13 to 20 days, while on plants showing no feeding it was from 9 to 22 days. Considerable feeding occurred on the leaves of turnip and cabbage with extreme longevity of 51 and 30 days, respectively, and also on the fruits and twigs of peach and fig, in which cases the extreme longevity was 73 and 50 days, respectively. The feeding on the last named plants appears to have been beneficial to the insects. Cucumber, squash, and cantaloupe plants were seriously injured by the feeding, and the extreme longevity in these cages

was 15, 32 and 20 days, respectively. One cucumber plant was killed by having been cut off at the surface of the ground, and one squash plant was killed by much chewing on the stem. Nevertheless, the longevity indicates no benefit to the insects from the feeding. Mating was observed on ten economic plants in cages 2, five of which were not fed upon, two of which showed trial feeding, and three of which showed considerable feeding. No eggs were laid in any of the cages containing economic plants only.

In cages 3, with both cactus and the economic plants available, the latter were entirely ignored except for very slight gnawing on the stem of a cotton plant. Otherwise, normal activities of feeding, mating, and oviposition were confined to cactus in which new broods of larvae became established, thus paralleling the activities of the species in cages 4.

#### EXPERIMENTS WITH FIRST STAGE LARVAE.

Due to the subterranean habits of the larvae of *Moneilema crassa*, the second series of tests was made in the field with growing plants instead of in glasses with cuttings. Fifteen eggs were used in each cage, these being placed just beneath the surface of the soil near the roots of the plants. Nine economic plants, providing physical conditions suitable for the larval development, and including sorghum, cotton, corn, peach, fig, pecan, grape, plum and apple, were tested. In cages 2 no feeding occurred on any economic plant and all larvae were dead at the end of two weeks. On cactus in cages 4 an average of 33 per cent of the larvae established themselves in normal fashion.

### DISCUSSION OF RESULTS FROM CAGE EXPERIMENTS.

The above results show that, under the stress of starvation, each species of insect attempted more or less feeding upon a varying number of the economic plants tested. It is further evident that in such instances the extreme longevity of the insects varied considerably. Examination of the several conditions bearing on the cause of this variation indicates that the physiological effects of the different plants are most largely concerned.

The age of individuals would no doubt affect their length of life under any circumstances but, since the required individ-

uals were drawn from large rearing stocks, this influence would tend to be well averaged. Again, the season of the year covered by the different tests would also likely affect the longevity of individuals tested; thus, in tests conducted in the season when activities were on the decline the length of life would undoubtedly be longer than in midsummer, other conditions being comparable. Finally, the different economic plants themselves varied greatly in regard to the degree of shading effect, and thus indirectly as to the conditions of temperature and moisture provided for the insects. However, neither the slight trial feeding nor the repeated feeding bears any constant relation to the amount of shading offered by the plants. It thus appears that in the instances of appreciable feeding upon economic plants a criterion of the beneficial or detrimental effect of such feeding may be found in the comparison of extreme longevity in such cases with the average of extreme longevity obtaining in all other cages operating during the same period and in which no feeding occurred.

Although the adults or large larvae of all species attempted to feed upon some of the economic plants, the least feeding tendencies were exhibited by the lepidopterous larvae. Indeed, the feeding attempts of *Mimorista flavidissimalis* were entirely negligible and those of *Olyca junctolineella*, while more numerous, were altogether temporary and did not appreciably increase the length of life. It is of interest to note that the more extensive feeding attempts of the latter were directed at those plants which offered the closest approximations to the physical conditions provided by Opuntia. Among the heteropterous species the feeding attempts of *Narnia pallidicornis* and *Chelinidea tabulata* produced no injury to the economic plants and were not correlated with increased longevity of the insects. The feeding of *Chelinidea canyona* caused slight injury to fig fruits, pea pods and agave leaves; the longevity of the insects indicates benefit from the former, while the feeding on the last two plants appears to have been detrimental. *Chelinidea v. aequoris* produced noticeable feeding injury on fig, peach and pea which was associated with increased longevity of the insects in all cases. The adults of *Moneilema crassa*, by rather promiscuous chewing, effected more general injury to economic plants than any other species; their feeding on fig, peach and turnip was correlated with noticeably increased longevity.

Thus the most varied as well as the most important feeding was displayed by *Chelinidea* v. *aequoris*, *Chelinidea canyona* and *Moneilema crassa*.

Among the economic plants some members of all families, except the Umbelliferae and the Compositae,[6] were subjected to trial feeding by one species of insect or another. The families including plants selected for trial feeding by the greatest number of insect species were the Chenopodiaceae, Moraceae, Cucurbitaceae, Rosaceae, Juglandaceae and Gramineae. Although a greater number of species of insects attempted to feed upon the chenopodiaceous plant than upon any other, the extent of such feeding was in all cases very slight. The only feeding correlated with benefit to the insects occurred on plants belonging to the Moraceae, Rosaceae, Leguminosae and Cruciferae. With the exception of the cruciferous plant, this more successful feeding occurred on the fruits of these plants. The fig (Moraceae) alone was of apparent benefit to all three of the above mentioned insects, the peach (Rosaceae) to two of them, and the pea (Leguminosae) and turnip (Cruciferae) each to one species. All factors considered, the feeding of *Chelinidea v. aequoris* was the most important, while the most satisfactory food provided by the economic plants was the fruit of the fig and the peach.

In cages containing both cactus and the economic plant, the insects constantly ignored the latter and lived in normal fashion on the natural host plant. Evidently, then, the feeding on other plants in the absence of cactus was due to the starvation factor and not to any instability of feeding habits on the part of the insects.

Attempts of first stage individuals to feed on economic plants were few and resulted in no development of such individuals, and they succumbed much more quickly in the absence of cactus than more developed individuals. These entirely negative results indicate that cactus is essential to the development of the first stage of all species tested. It is interesting to note that, of the heteropterous species, whereas the adults of *Narnia pallidicornis* exhibited the least amount of feeding recorded, the newly-hatched individuals indulged in the most trial feeding on economic plants.

[6] *Ambrosia artemisiaefolia* L., a common weed belonging to this family, was fed upon by *Chelinidea v. aequoris* and *C. canyona*.

When confined with economic plants only, mating on the part of both the heteropterous and coleopterous adults was of fairly frequent occurrence and the heteropterous adults also deposited eggs in many cages. The eggs were laid partly on the economic plants and partly on the cages themselves. In the preferential tests, with the exception of *Chelinidea tabulata*, eggs were laid on economic plants only in a few exceptional instances.

Heretofore the term feeding, has been employed in its broadest sense, without the usual implication of survival of the participants and reproduction of the species. The feeding of these cactus insects was in no case followed by survival and reproduction, and, since the instances cited occurred only under the stress of starvation, they may not be construed as indicative of unstable feeding habits.

From the experimental work it appears that the adults, with cactus available, selected it for oviposition as well as for feeding. The data also show that neither the older nor the newly-hatched individuals were able to survive on the economic plants tested.

## NATURALLY LAID-OUT EXPERIMENTS.

To secure data entirely uninfluenced by the starvation factor present in cages 2, a number of naturally-laid-out field experiments was conducted. Having selected plots of cactus immediately adjacent to economic plants, the species of cactus insects present in the cactus plot were first determined, and then the nearby economic plants were minutely examined for any stages of these insects.

Five such examinations were made at Uvalde, Texas, and involved tomato, sorghum, bean, corn, watermelon, cantaloupe, pumpkin, agave, peach, pear, fig, pecan, plum, grape, and apple as well as all the insects in question except *Chelinidea canyona* and *Moneilema crassa*. Two examinations made by Mr. T. C. Barber at Brownsville, Texas, included cotton, corn, bean, onion, squash, orange and grapefruit and all the insect species except *Chelinidea canyona*, *Moneilema crassa* and *Narnia pallidicornis*. In no case was any stage of the cactus-feeding insects found on any of the easily accessible economic plants.

## CONDITIONS INDICATING RESTRICTION OF FEEDING HABITS.

The tenor of the experimental work was so overwhelmingly against the possession of unstable feeding habits that the tests were not repeated, for, although each repetition would increase the validity of the results, any number of repeated tests giving negative results would fail to provide absolute assurance that the insects would not attack other plants. On the other hand, an examination of all available data bearing upon their restriction appeared especially valuable in conjunction with the experimental results.

### COLLECTION RECORDS AND FIELD OBSERVATIONS.

Records of the United States Bureau of Entomology on the host affiliations of American insects have been built up over a long term of years, yet they contain no references to the occurrence of these cactus insects on other than cactaceous plants. It is true, however, that these records, for the most part, resulted from general collecting and observations and from the collection of insects on particular economic plants rather than having been assembled through observations directed toward determining the hosts of these species.

The above records are supported by the writer's own experience in the field during several years devoted to the collection and study of cactus insects. These studies extended to many regions of North America with varied environmental conditions and, although constantly on the alert for the occurrence of these species upon other plants, no such instance was encountered.

Taken together, the extensiveness of the one and the intensiveness of the other observations without a single detection upon other plants, these findings constitute weighty evidence indicative of the normal dependence of these species upon the cactus family.

### FOOD HABITS OF RELATED INSECTS.

The degree of host restriction exhibited by congeners or species in related genera is often valuable in indicating the probable feeding habits of the species in question. Unfortunately, incomplete knowledge of food plants or confused classification detracts from the usefulness of this criterion.

Nevertheless the following digest of pertinent facts provides worth-while indications concerning the eight species under consideration.

The genus *Chelinidea*, all four species of which are recorded only from cactaceous plants, is in the family *Coreidae* which tends to be oligophagous or strict oligophagous. *Chelinidea* is treated in the tribe *Coreini*, but is not closely related to the other genera thereof. Likewise, all species of *Narnia* are recorded only from cactus plants; this genus is closely related to *Leptoglossus*, the species of which are chiefly oligophagous to monophagous. In the case of *Dactylopius* also, the records show no hosts other than Cactaceae for any of the species. This genus, however, is not closely related to the other genera of the subfamily to which it attaches. *Olyca junctolineella* has five congeners, but their food plants are unknown. Moreover, knowledge of the hosts of related genera is incomplete, but three very closely related genera (*Melitara*, *Cactoblastis*, and *Cactobrosis*) contain cactus-feeding species. The two species of *Mimorista* feed on cactus, but this genus is considered by some to be a synonym of *Samoedes* Snellen, which embraces some forty species from all parts of the world. The genus, however, belongs in the subfamily Pyraustinae which contains some general feeders such as *Pyrausta nubilalis* Hbn. *Moneilema*, the many species of which are all recorded only from cactus, was formerly placed in a separate tribe and now, although treated in Dorcadionini, has no very close relatives therein.

We thus see that the congeners of *Chelinidea vittiger*, *C. tabulata*, *C. canyona*, *Narnia pallidicornis*, *Dactylopius tomentosus*, and *Moneilema crassa* all possess strict oligophagous food habits, being recorded only on cactus plants. *Olyca junctolineella* is excepted because the food habits of its congeners are unknown, and *Mimorista flavidissimalis* because of polemical classification. Furthermore, genera related to *Narnia* and *Olyca* are possessed of oligophagous to strict oligophagous food habits, while *Chelinidea*, *Dactylopius*, and *Moneilema* are remotely related to the other genera of the major groups in which they are placed.

## COINCIDENT DISTRIBUTION.

The Cactaceae are native to the Americas, and the genus Opuntia, which chiefly concerns us here, occurs in nature from

Massachusetts to British Columbia and southward to the Strait of Magellan (2). Despite this wide distribution, it is an outstanding element of the flora only in semi-arid and arid

FIG. 3. Approximate distribution of cactus and cactus insects.

regions. In North America the main cactus area includes the southwestern United States, as shown in Fig. 3, and Mexico.

The distribution of particular species of cactus insects, also shown in Fig. 3, is generally much more restricted than that of Opuntia. Thus, one of the eight species here treated occurs only in southwestern Texas, and two others are restricted to southern Texas and adjacent northeastern Mexico. Two more species inhabit the Mexican tableland and extend their range into southwestern and southern Texas. Two other species range widely over Mexico, and from Texas to California. Finally, one widely distributed species occurs from California and Idaho to Virginia and Florida, and in northern Mexico.

Figure 3 emphasizes the fact that all eight species of insects are limited to the region occupied by Opuntia, and all except one range entirely within the principal cactus area. This coincident distribution argues strongly against the subsistence of these insects upon non-cactaceous plants.

## BIOLOGICAL ISOLATION.

The Cactaceae constitute the single family of the order Cactales which Shaffner (*14*) treats as a primitive group of the subclass Myrtiflorae, although he states that cactaceous plants are so distantly related to the other Myrtiflorae as perhaps to justify ranking them as a distinct subclass. The Mesembyanthemaceae are thus placed as distant relatives of cactaceous plants. Representing a higher evolutionary level in the main series of Myrtiflorae, is first the genus *Begonia*, and finally the culmination in the Cucurbitaceae. It is thus possible to trace a remote line of relationship from the Cactaceae to the Cucurbitaceae by the way of the ice-plant (*Mesembryanthemum crystallinum* L.), New Zealand spinach (*Tetragonia expansa* Murr.), and *Begonia*. Notwithstanding, the many divergent features of the Cactaceae set the family apart as a distinctly isolated group in the plant world.

This botanical isolation at once suggests that the cactus family might be found to support groups of insects more or less peculiar to itself. That this condition actually exists is revealed in a preceding section where it appears that three genera certainly, and possibly two others, of the six under study occupy isolated positions among other genera of insects. We are thus led to conclude that cactus and its insect associates enjoy marked biological isolation.

### SPECIALIZATION OF CACTUS INSECTS.

The sluggishness or infrequent flight exhibited by the adults of several cactus insects appears to be correlated with the high degree of protection afforded by the cactus plant. The large *Olyca* moths and *Moneilema* beetles are extremely sluggish in all actions; the former rarely use their wings for flight, while the latter have rudimentary wings beneath fused elytra. The three species of Chelinidea, although active enough on foot, make little use of their well-developed wings. On the contrary, the *Narnia* bugs and *Mimorista* moths are quite active in flight and otherwise.

Again, the ovipositional habits of three species of *Chelinidea*, *Narnia pallidicornis*, and *Olyca junctolineella* indicate much specialization to the Cactaceae. The laying of eggs in rows on the cactus spines by the heteropterous species and the construction of egg-sticks on the tips of spines by the lepidopteron are at considerable variance with the general habits found in those groups. The spines of cactus are themselves highly modified structures and the adaptation of ovipositional habits to them provides strong evidence of the long association of the insects with cactaceous plants.

## CONDITIONS AFFECTING AVAILABILITY OF OTHER PLANTS AS HOSTS.

The botanical isolation of the Cactaceae and the geographical distribution of the family denote possession of certain physical, functional and seasonal peculiarities. Several of the insect genera are also isolated taxonomically and others show specialization to cactus. These circumstances indicate that the biologies of the insects are conditioned by the special features of cactus, and it is therefore appropriate to inquire whether such insects could find the requisite conditions elsewhere in the plant world. In the following discussion special reference is had to the platyopuntias, which predominantly serve for the breeding of the insects under study.

### SPECIAL FEATURES OF PLATYOPUNTIAS.

The continuous availability of the platyopuntias throughout their range is remarkable, affording as they do abundant and relatively unchanging herbaceous material at all seasons.

Moreover, availability from year to year is assured by their phenomenal ability to withstand the protracted droughts to which their habitat is subject. Again, the physiology of Opuntia is strikingly different from that of most plants in that the entire photosynthetic functions are exercised by the stems and this specialized physiology has resulted in a chemical constitution of the stem very different from that of the trunks and stems of other perennial plants. Finally, the physical attributes of the platyopuntias, such as the thickness and succulence of the joints, are infrequently encountered among non-cactaceous plants.

Few plants match the combination of characters just mentioned. Trees and shrubs are the principal exceptions in providing continuous availability, but functionally they differ greatly from the platyopuntias. Texturally, also, their constitution is very dissimilar to platyopuntias except as regards the fruits of some, but these parts are available for comparatively brief periods only.

## BIOLOGICAL REQUIREMENTS OF THE INSECTS.

Let us now examine the biologies of the insects under consideration to learn if any of the special features of the platyopuntias are essential to their mode of life. First we see that the physical features of these plants are essential to the development of the large internal-feeding larvae of *Olyca junctolineella* and *Moneilema crassa*. Among economic plants few supply parts of sufficient thickness and succulence to accommodate these two species.

Again, the seasonal requirements of some of the insects are extremely rigid. Thus, *Dactylopius tomentosus* feeds throughout the year, the development of the winter generation merely being retarded. Furthermore, this species is free-living for only a brief period in early life and is therefore incapable of existence without a continuous food supply. Thus, without several changes of hosts during the year, this cochineal insect could live upon few plants, providing like physical conditions, other than Opuntia. Similarly, *Olyca junctolineella* and *Moneilema crassa* exist in the larval stage during the greater part of the year and therefore require a continuously available host plant. Together with certain physical characteristics, as was

above noted, *Mimorista flavidissimalis*, producing eight generations annually and being restricted to the new growth for food, has requirements difficult to find among plants other than Opuntia. The heteropterous species require cactus only about eight months of the year for feeding but, even in satisfying this requirement of availability, few plants approach cactus. It is therefore evident that, aside from cactus, few plants of similar physical structure answer the seasonal requirements of these insects.

### PHYSIOLOGICAL ADJUSTMENT TO CACTUS.

The remarkably constant availability of cactus above cited has provided conditions highly favorable to the establishment of an extremely close chemical relationship between this plant group and its insect associates.

Insects accepting such omnipresent plants as food would seem to have no incentive for seeking other less constant sources of food, and available records render most reasonable the assumption that these species have, for a considerable term of years at least, fed upon a relatively unchanging food. Such association for innumerable generations with one particular group of plants would probably be reflected in their physiology, tending, through selective elimination, to render them more and more dependent upon the chemical constituents of those plants. This accommodation to particular hosts on the part of insects, the operation of which would be fostered by the constancy of such hosts, appears to be one of the basic factors active in establishing closer restriction to host plants.

The result of this tendency to bind insect species to particular plant groups would undoubtedly be more inflexible in the cases of insects feeding upon a highly differentiated group of plants. Thus the stability of feeding habits of these strict oligophagous species is strengthened by their association with such an isolated group as the Cactaceae.

In view of the above statements these insects would seem to require a powerful incentive to seek subsistence upon other plants and a high degree of adaptability for successful change. The one condition is invalidated by the constancy of cactus in the flora, while the other appears to have been negatived by the physiological adjustment to cactus.

PLANT REACTION TO INSECT ATTACK.

Another potential factor in limiting the availability of other plants as hosts for these cactus insects is the reaction of plants to insect attack. A most interesting example of such plant activity occurred in Queensland in connection with *Dactylopius tomentosus* and, although obtaining within the Cactaceae, will serve to illustrate the point.

This cochineal insect is not found feeding indiscriminately upon Cactaceae. It even shows marked preferences for certain groups of Opuntia, there being three distinct biological strains. During the Australian summer of 1923 the writer had at hand cultures of these strains still living on American Opuntias, and undertook to establish them upon several of the Australian pest species of Opuntia. Two cages were devoted to the establishment of the Arizona strain of the cochineal, originally taken in nature from an Opuntia of the *Phaeacanthae* series, upon the "common pest pear," *Opuntia inermis* De Candolle. A great superabundance of cultures of mature females was caged with *O. inermis*, upon which very large numbers of crawlers settled. However, only an infinitesimal proportion of them survived longer than a few days. It was discovered that thickened, brownish, corky areas surrounded the points of insertion of the probosces of the dead crawlers. Thus the crawlers, when forced to go on a species of Opuntia of another type than that to which the race was accustomed, were killed by what was probably proliferation of the epidermal cells, which finally closed about the probosces and cut off the food supply. By the addition of other abundant cultures of females at intervals, a constant and large production of crawlers was maintained. After several weeks a sparse culture was established on *O. inermis* which developed to maturity. The succeeding generation of crawlers from these females readily established themselves upon *O. inermis*, and today the strain is breeding on this Opuntia in Australia in a thoroughly satisfactory manner.

Less definite reactions of the same nature in connection with the other strains of this cochineal insect support the belief that such reaction varies to some extent at least with individual plants, although grown at the same place.

Plant reaction to insect attack is also indicated in the tests of *Chelinidea tabulata* adults on cotton and of the nymphs on

onion. Reference is here made to the individuals which died with their probosces inserted in the plants. The fatal reactions in these instances were, however, quite different from those observed with the cochineal, being apparently due to chemical unsuitability of the cotton and onion plants. Plant reaction of this nature would be revealed against the heteropterous species in such definite form only in the most exceptional instances. The very brief duration of life of the insects in other cages indicates the more general operation of this factor in the tests.

## FACTORS INVOLVED IN THE HOST RESTRICTION OF OTHER INSECTS.

Coad (*4*), working with the monophagous cotton boll weevil (*Anthonomus grandis* Boh.), has shown experimentally that this insect may produce normal fertile eggs after feeding upon *Hibiscus syriacus* L. and may also complete its development in the buds of this plant. Although this hibiscus occurs in the midst of large areas of cotton infested by the weevil, it has never been found breeding in the hibiscus. The limiting factor in this case is undoubtedly a growth phenomenon which allows the infested buds to open and shed the weevil eggs or larvae.

Extensive tests by Mosher (*12*) have shown that the polyphagous larvae of the gypsy moth (*Porthetria dispar* L.) feed with varying success on the different host plants. In fact, on the basis of their suitability for larval development, the food-plants were grouped as follows: first, favored species; second, species favored after the early larval stages; third, species not favored but on which a small proportion of larvae may develop; and fourth, unfavored species. This varying suitability is clearly based upon physiological effects upon the larvae.

The work of Craighead (*5*), chiefly with polyphagous and oligophagous wood-boring Cerambycidae shows that, in general, a species having developed in one of the several species of wood which it infests in nature, will infest this particular wood more heavily than the other natural hosts of the species. There is also evidence in this report that the adults select for oviposition the hosts in which they fed as larvae, but in many cases the larvae died in wood so selected. Furthermore, it appears that,

since the degree of larval infestation and not the comparative deposition of eggs was the basis for determining host preference in this investigation, what the work actually shows is the ultimate restriction to hosts, this being the resultant of larval survival acting upon the host selection exercised by the adult. Thus, aside from any selectional activity of the adults, the physiological relationships of the immature stages to the hosts appear to be chiefly responsible for the restriction displayed.

Fulton (*6*) has shown that the principal factor determining the restriction to different groups of host plants of the two physiological races of *Oecanthus niveus* De Geer is the size of the stems selected for oviposition.

The work of Larson (*11*) shows that *Bruchus quadrimaculatus* Fab. selects the larval food on the basis of the character of surface offered by various seeds. However, many seeds that satisfy the conditions requisite for oviposition are unsuitable for larval development. Here, again, the physiological influence of the host appears to be the final agency governing the host restriction.[7]

To these instances may be appended the case of *Dactylopius tomentosus* (Lamarck) above mentioned, in which the different biological strains appear to be maintained by plant reaction in the nature of epidermal proliferation.

There are also many references in literature relating to the role of internal and external stimuli in governing oviposition, and thus indirectly determining the larval food. Richardson (*13*) believes that most free-living species require a chain of stimuli to provoke egg-laying, and that many species demand a specific chain of stimuli.

## SUMMARY AND CONCLUSIONS.

1. Eight species of North American cactus-feeding insects have been studied as regards the safety to Australian agricultural interests of importing them to combat naturalized Opuntias.

2. Several lines of inquiry show that these insects are

[7] Timberlake (*15*) found an analagous situation with a parasite. *Linnerium validum* (Cresson), commonly parasitic on larvae of the fall web-worn oviposited in several other caterpillars in the absence of its usual host; but development was rarely completed due to the death of the newly-hatched parasite larvae occasioned by amoebacytes of the host.

closely restricted to the Cactaceae, the coccid, *Dactylopius tomentosus*, showing the closest restriction and the coreid, *Chelinidea v. aequoris*, showing the greatest degree of adaptability to economic plants.

3. The various degrees of restriction to cactaceous plants are based upon one or more factors, of which the following are the more important:

(a) Physiological adjustment of the insects to cactus.
(b) Biological requirements of continuously available host plants.
(c) Biological requirements of the physical conditions provided by cactus, especially those of the subgenus, Platyopuntia.
(d) Plant reaction to insect attack.

4. Newly-hatched larvae of the cactus insects are less adaptable to new host plants than the more mature individuals.

5. Fruits, such as those of the fig and peach, provided the most satisfactory food of the series of economic plants.

6. Although the climatic conditions of eastern Australia from the coast toward the interior parallel in a general way the climatic changes encountered from the Gulf coast of Texas to Arizona, it is conceivable that there may be factors operating in the new environment which, although unknown, may permit a change of food habits on the part of some of the insects. Such eventualities are, however, considered extremely remote and are not amenable to experimental determination.

7. The peculiarities of cactus, which mark it as a distinctly isolated botanical group, give to this introduction the greatest degree of safety possible in the importation of plant-feeding insects for biological control of noxious vegetation.

8. The general isolation of the genera of insects embracing the cactus-feeding species from the other genera of major groups is indicative of a high degree of specialization with adaptation to the isolated Cactaceae.

9. From published researches on different types of insects it is evident that a considerable number of varied factors may determine the restriction of feeding habits of phytophagous insects. Thus, while the instinctive selection of hosts exercised by the adults of many species in connection with oviposition is of great importance in preserving the food habits of insects, the availability of the plant with regard to the biologies of the insects appears to operate as a check against erratic oviposition. All in all, it is concluded that the host restriction of

phytophagous insects may be determined by one or several of a number of factors, of which no one nor any one group is of constant dominance in such limiting action.

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## BOOK NOTICE.

**THE PLANT LICE, OR APHIIDAE OF ILLINOS, I by F. C. Hottes and T. H. Frison, Natural History Survey of Illinois Bulletin, Vol. XIX, Article III, pp. 119–447, 50 text figures and 10 plates.**

**Against our rule of noticing "articles" we wish to call attention to this volume of keys and descriptions of the aphids of Illinois. Part I is introductory, Part II is systematic and Part III has keys to species grouped with reference to host plants. The volume follows a campaign of extensive collecting in the various ecological regions of the state which added approximately a hundred species to the state list, thirty-six of which were new to science. The work shows what carefully planned collecting will do as the aphids of Illinois had been studied by previous aphidologists since the time of Walsh. We are just beginning to find that our Central States are dotted with ecological pockets and little islands with special faunas that well repay searching out. The keys and plates of structural details make the volume generally useful.—C. H. K.**

# MICROGASTER TIBIALIS NEES AS A HYMENOPTEROUS PARASITE OF PYRAUSTA NUBILALIS HUBN. IN EUROPE.

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*Microgaster tibialis* Nees is a braconid which occurs as a rather important solitary parasite of the European corn borer (*Pyrausta nubilalis* Hübn.) in several parts of Europe. Importations of it into the United States from France were begun in 1923 by W. R. Thompson and H. L. Parker, of the European Parasite Laboratory, Hyères, Var, France, and since that time large numbers of the parasite have been collected and shipped each year. For the entire period 1923 to 1930, inclusive, a total of 587,062 Microgaster cocoons were collected in Europe and shipped to the U. S. Entomological Laboratory, Arlington, Mass., where they were handled under the direction of D. W. Jones.

[1]In preparing this paper the writer has drawn freely on the data accumulated by W. R. Thompson and H. L. Parker during nine years' work on the parasites of *P. nubilalis* at the European Parasite Laboratory, Hyères, Var, France. He expresses his appreciation to H. L. Parker, now in charge of the Hyères laboratory, and to H. D. Smith, an associate, for their helpful suggestions. He is also very grateful to C. F. W. Muesebeck for his kindness in furnishing a redescription of the species, and to Esther Hart for her drawing of the adult.

This paper aims to collate various data on the distribution, economic importance, and biology of this parasite as a factor in the control of the corn borer in its European habitat, to provide an adequate description of the adult, and to present certain morphological characters of the immature forms which may aid in the identification of the species.

## PREVIOUS REFERENCES.

No attempt will be made to review all of the literature relative to this species which, as Thompson and Parker (*11*) have pointed out, is probably identical with the parasite described by Marshall (*9*) under the name of *Microgaster globatus* Nees and which has various host relations. Rather, the writer will confine himself to a brief review of the work done with the species as it has been found parasitic on *P. nubilalis* only, and the following references pertain to this host relation alone.

Thompson and Parker, in the above-cited publication, have considered briefly but comprehensively the distribution, biology, limiting factors, and extent of parasitism of *M. tibialis* for the years 1925 and 1926, and Parker *et al.* (*10*), have tabulated data on its economic importance from 1926 to 1928.

In 1924, Jones (*5*) mentioned *M. tibialis* as one of the foreign parasites then being introduced into the United States, and stated that most of the problems connected with its breeding had been solved. Later (*6*), he published the technique used in the quantity production of this parasite in the laboratory, and included photographs of the adult male and female.

Two papers, similar in character, by Ellinger and Sachtleben (*3*, *4*), discussed the synonymy of the species and illustrated the adult female and the color variations observed in the hind legs of *M. tibialis* and *M. globatus*.

Zwölfer (*13*)[2] published a few notes on this species, which he found attacking the corn borer at Rastatt, Baden, Germany. A little later, in another publication (*14*), he presented the same data supplemented with a discussion of the biology and seasonal history of the parasite in southern Germany, but stated that he was unable to breed Microgaster in the laboratory.

[2]This author in his publications gave drawings of the adult male, the abdomen of the female, a larva (probably last stage), and the so-called head capsule of a larva (also probably last stage, but too lacking in detail to permit of identification), and in a photograph showed adults and cocoons of the species.

The parasitism by Microgaster in Baden, Germany, in 1928, was studied by Kunike (*8*), who reported on its economic importance in that region.

Other references to this parasite of the corn borer have been made by Caffrey and Worthley (*2*), Jones and Caffrey (*7*), and Thompson (*12*). The last author illustrated the adult and cocoon of Microgaster.

## GEOGRAPHICAL DISTRIBUTION.

*M. tibialis* appears to be distributed over most of Europe. Thompson and Parker (*11*) record it as a parasite of the corn borer from Artemisia in the northern, northwestern, and northeastern parts of France and from corn in northern Spain, southwestern France, and Baden, Germany, and in the Po Valley and the region of Naples, Italy. It has since been found attacking the corn borer in northeastern Italy in the general vicinity of Padua, and near Ferrara where the host was infesting both corn and hemp. At Sermide, Italy, one specimen was found in Xanthium. Parker *et al.* (*10*) have also noted it from corn borer larvae collected in the region of the Dnieper River in Russia. Its points of concentration, however, seem to be in the north of France in the regions of Lille and Paris and in the Po Valley of Italy near Bergamo.

## ECONOMIC IMPORTANCE.

Thompson and Parker (*11*) and Parker *et al.* (*10*) have presented statistics on the parasitism of this species in certain years between 1925 and 1928, inclusive, in the various parts of Europe, where their studies have enabled them to get such information, and Parker, Vance, and Smith[3] have tabulated similar data for 1929. The parasitism by Microgaster in Baden, Germany, for the years 1926 and 1927 was studied by Zwölfer (*13*, *14*) and for 1928 by Kunike (*8*). It is the purpose of Table I to summarize these and to add other data that will complete the record for the entire period 1922 to 1930. The various zones listed have been defined by Thompson and Parker, and Parker *et al.*, in two of the publications (*11*, *10*) cited above.

The most effective control exerted by *M. tibialis* on the corn borer has been observed in Artemisia in the Sequanian (south) zone in the general region of Paris, France, where the

[3]Unpublished manuscript.

TABLE I.

Average Percentage of Parasitism of *Pyrausta nubilalis* in Corn, Artemisia, and Hemp by *Microgaster tibialis* in the Various Zones of Europe, 1922–1930.

| Year and Generation | Aquitainian | Vosgian | | Sequanian (north) | Sequanian (south) | Armorican | Campanian | Padovian (north) | Padovian (south) | | Venetian | Galician | Rhodanian | Dansprisian | Central |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Corn | Corn | Artemisia | Artemisia | Artemisia | Artemisia | Corn | Corn | Corn | Hemp | Corn | Corn | Artemisia | Corn | Artemisia |
| 1922: Generation I | | | | | 11.3 | | | | | | | | | | |
| 1923: Generation I | | | | | 19.9 | | | | | | | | | | |
| 1924: Generation I | | | | 16.3 | 25.9 | | | 1.5 | | | | | | | |
| Generation II | | | | | | | | 0.4 | | | | | | | |
| 1925: Generation I | | 1.4 | 13.8 | 10.0 | 63.2 | 0.4 | | 3.7 | 0.2 | | | 2.9 | 2.7 | | |
| 1926: Generation I | 0.05 | 3.06[1] | 2.2 | 18.0 | 52.5 | 0.2 | —0.01 | 3.2 | | | | | | | |
| Generation II | | | | | | | | 0.1 | | | | | | | |
| 1927: Generation I | 0.1 | 6.2[2] | | 13.2 | 31.3 | 0.1 | | 15.0 | | | | | | | |
| Generation II | | | | | | | | 0.1 | | | | | | | |
| 1928: Generation I | 0.7 | 9.8[3] | | 21.5 | 26.6 | 0.1 | | 7.3 | | | 0.3 | | | 1.3 | |
| 1929: Generation I | 0.2 | | | 19.6 | 6.7 | 0.7 | | 1.9 | 0.6 | 7.3 | 3.2 | | | | |
| Generation II | | | | | | | | | 0.03 | | 0.02 | | | | 0.08 |
| 1930:[4] Generation 1 | | | | | | | | 7.2 | 0.9 | 3.8 | 0.2 | | | | |

[1]This one figure represents the maximum, rather than the average, percentage of parasitism, in Baden, Germany, for that year. From studies of Zwölfer. (See literature cited.)
[2]From studies of Zwölfer. (See literature cited.)
[3]From studies of Kunike. (See literature cited.)
[4]Data for this year incomplete.

average parasitism for eight years (1922–1929, inclusive) was 29.7 per cent, with maximums of 63.2 and 52.5 per cent in 1925 and 1926, respectively. In 1927 the percentage was only half that of 1925 and in 1928 only half that of 1926, with a much more decided drop to 6.7 per cent in 1929.

Pyrausta collections in Artemisia in the Sequanian (north) zone with Lille, France, as the center, have furnished a rather consistent quantity of Microgaster, varying from a minimum of 10 per cent in 1925 to a maximum of 21.5 per cent in 1928, with an average of 16.4 per cent for a six-year period (1924–1929, inclusive).

Next in importance, from data of the writer, this parasite has been most effective in *P. nubilalis* larvae of the first generation in corn in the Padovian zone near Bergamo, Italy. In this region the average parasitism for a seven-year period (1924–1930, inclusive) was 5.7 per cent. In the Vosgian zone Zwölfer recorded an average of 6.2 per cent in the first generation of Pyrausta in corn in 1927, and Kunike reported a parasitism of 9.8 per cent for 1928. Parasitism in some of the other zones, while in most cases considerably less than for any of the above, has nevertheless been sufficient to be of some economic importance.

## DESCRIPTIONS.

### Adult (Text Fig. 1).

The following complete description of the adult of *M. tibialis* Nees was prepared by C. F. W. Muesebeck:

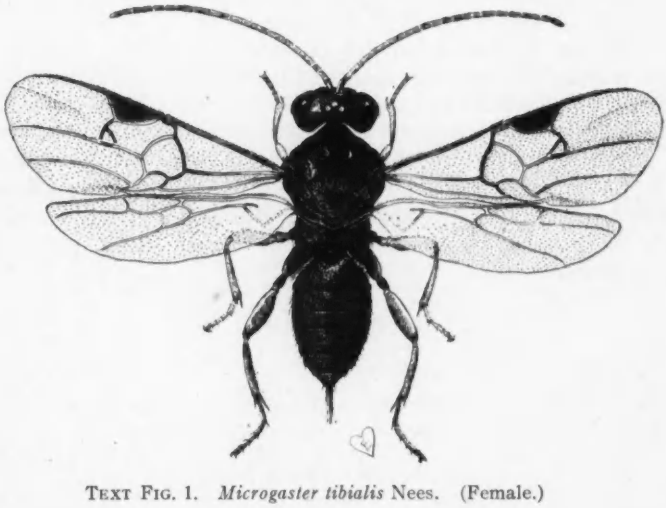
**Microgaster tibialis** Nees.

(Text Fig. 1)

"*Female.*—Length, about 3.5 mm. Head a little narrower than thorax; face, including clypeus, confluently punctate or rugulosopunctate and opaque; temples and cheeks rounded, not receding directly behind the eyes; vertex medially behind ocelli finely transversely sculptured and subopaque; antennae a little shorter than the body; thorax stout; mesoscutum finely punctate anteriorly, polished behind; scutellum polished, nearly flat; propodeum short, strongly declivous, entirely closely rugulose and with a prominent median longitudinal carina; mesopleura mostly smooth and with a pit-like impression posteriorly; abdomen very nearly as broad as the thorax; chitinized plate of first tergite large, about as broad at apex as long, closely rugulose; membranous margins of first tergite very narrow, usually apparent only at extreme apex; second tergite transverse, about three times as broad as long, and entirely closely rugulose; following tergites

smooth and shining, with only setigerous punctures; ovipositor sheaths broad, and as long as the abdomen beyond second tergite; anterior wing with the stigma large, as long as the metacarpus; radius longer than first intercubitus and strongly inclined outwardly; posterior coxae mostly smooth; inner spur of posterior tibia two-thirds the length of metatarsus. Head, thorax, and abdomen entirely black; antennae black; wings weakly dusky on the apical half; stigma unicolorous, dark brown; all coxae and trochanters black; anterior and middle femora blackish at base; posterior femora usually testaceous to yellowish-brown, more or less varied with black; all tibiae testaceous, the posterior pair blackish at apex; posterior tarsi dusky.

"Except for the somewhat longer antennae and other secondary sexual differences, the male closely resembles the female."



TEXT FIG. 1. *Microgaster tibialis* Nees. (Female.)

## EGG.

The egg (Pl. I, Fig. A) of Microgaster measures 0.504 mm. in length and 0.072 mm. at its greatest width. It is circular in cross section and slightly curved in shape, translucent white in color, and has a smooth surface. From the cephalic end, which is bluntly pointed, the egg thickens slightly and then becomes much more slender for about half of its length to terminate in a short petiole.

## FIRST-STAGE LARVA.

Late first-stage larva. Length of body, 2 mm., width, 0.52 mm.; length of anal appendage, 0.36 mm.; length of mandible, 0.056 mm.

The larva of *M. tibialis* (Fig. B), shortly after emerging from the egg, has a rather square head followed by three thoracic and eight

abdominal segments. The last abdominal segment is approximately three times as long as any of the others and terminates in a long slender anal appendage. On the dorsal surface of the third thoracic and on each of the eight abdominal segments a few short spines are directed posteriorly. In color the larva is translucent white.

Within the mouth are two long well-chitinized mandibles (Fig. C), curved slightly and pointed at their tips. Two processes, capable of being protracted and retracted, extend forward from the region above the labrum. On the labrum are three small sensorial areas, one in the center, and one near the base of each of the labral processes.

By the time that the larva is a few days old a slight evagination of the anal vesicle is visible on the dorsal surface of the last abdominal segment and this becomes more pronounced as the larva continues its growth. No tracheal system or open spiracles are developed in this stage.

### Second-Stage Larva.

The larva of this stage is characterized, like that of many braconid larvae, by its increased size, a smooth body, a prominent round anal vesicle, and a very weakly chitinized and non-pigmented head. The spiracular system is still apneustic.

### Last-Stage Larva.

Length of larva, 5.5 mm.; width, 1.5 mm.; length of mandible, 0.184 mm.; diameter of spiracle, 0.04 mm.

The last-stage larva of *M. tibialis*, in general form and structure, is similar to other closely-related braconid larvae of the same stage. The body consists, as usual, of the head and three thoracic and ten abdominal segments. Each body segment except the last possesses a considerable number of sharp spines. Spiracles open on the second thoracic and first seven abdominal segments. (The arrangement of the spines and spiracles is shown in the drawing of the prepupa, Fig. E.)

One convoluted silk gland, bifurcating in the thoracic segments, occurs on each side of the larva, and two long slender Malpighian tubes leave the hind intestine and continue forward along the ventral side of the mid-intestine.

### Head of Last-Stage Larva of *Microgaster tibialis* Nees.

(Pl. I, Figs. F, G.)

The following description is based on a study of live larvae in both air and water, specimens treated with caustic potash solution, and balsam-mounted material.

The upper portion of the epicranium is greatly attenuated so that the antennae are situated near the postocciput at the posterior border of the head.

Head covered with short protuberances; postocciput (*po*) wide and distinct in lower half from its junction with hypostoma almost as far as antennal area, somewhat broken by antenna (*a*), then continued as a thin band to apex of head, light brown for a short distance above

antenna; metopic suture (*ms*) distinct, wider at vertex where it is longitudinally striate, unpigmented; a very small unpigmented round depression present on each side of the wider basal portion of the metopic suture, and anterior to the postocciput; frons not well differentiated; frontal sutures (*fs*) indicated by short weak horizontal lines; antennae border on postocciput, small, roughly oval with cleared oval area at center, small area on dorsal portion light brown like adjoining postocciput; dorsal tentorial pits (*dtp*) as slightly depressed, cleared, and more or less circular areas ventrad of the lateral extremities of frontal sutures; labrum (*lm*) bilobed, lobes separated by a dorso-ventral groove, each lobe with four small regularly arranged papillae and one larger circular area, cuticle in region of papillae slightly brownish; maxilla with one palpus and one seta; short thickening from anterior part of hypostoma goes ventrad part way across maxilla, brown, blunt at extremity; thickening along ventral border of maxilla (*mxt*) heavy, brown, extending laterally from mid-lateral edge of labial thickening almost to hypostoma, where it widens slightly; labial thickening (*lbt*) squared in shape, open dorsally, strongly sclerotised, brown, very wide in ventral portion; slitlike orifice of salivary duct (*sdo*) between dorsal extremities of labial thickening; one pair of palpi and one pair of setae on portion of labium enclosed within thickened border; two small circular areas just below orifice of salivary duct; anterior part of hypopharynx, or glossa (*g*), covered with many closely-placed protuberances; epistoma (*ep*) very thin, indistinct; pleurostoma (*pl*) short, with superior and inferior pleurostomal branches, brown, of about equal length and arranged in V-shape; hypostoma (*hy*) well sclerotised, brown, uniting with postocciput at side of head; two groups of long spines (five, more or less, in each) below labial thickening; very short tentorial points leaving ventral extremities of postocciput, thick, blunt; no transverse tentorial bar; dorsal tentorial arms each indicated as a short sclerotised fibril attached to internal surface of each dorsal tentorial pit; few spines, arranged on genal region of head; mandible (Fig. D) with long sharp distal point, an adjoining short dorsal tooth, and about twenty saw-like teeth along inner edge.

### Prepupa.

The prepupa (Fig. E), or stage between the larva and pupa in which this parasite overwinters within its cocoon, differs externally from the last-stage larva in its decreased motility, the more distended abdominal segments, and the stretched-out appearance of the thoracic segments. The pulling away of the cephalic organs of the larva from within the exoskeleton of the head leaves this structure more transparent, and the brown eye spots of the pupa are prominent on the upper posterior portion of the first thoracic segment.

### Pupa.

The pupa measures 5 mm. in length and 1.78 mm. in width. It is of the free or exarate type common to the Hymenoptera and lies free within the cocoon. When fully formed, the pupa has taken on the colors of the adult insect.

### Cocoon.

The cocoon of this Microgaster averages 6 mm. in length and 2 mm. in greatest width (at the middle). It is circular in outline and roughly oval in shape, but with the two ends broadly rounded and sometimes even rather truncate. It is normally white but certain cocoons collected from borer tunnels in Artemisia have a dirty brownish hue, probably due to contact with the sap of the plant.

The cocoon is closely woven and tough, with very few loose threads on the external surface. Exteriorly it has a dull appearance; inside, it is lined with a thin white shiny membrane which can be separated from the thicker outer layer. The very cephalic extremity is decidedly thickened to form a cap which can be cut off neatly by the emerging adult.

## BIOLOGY.

The adults of both sexes are positively phototropic and in the laboratory always move toward a source of light. Mating was obtained and the fertilized female was found capable of depositing several hundred eggs during a normal lifetime. One dissected female contained 292 eggs in her ovaries. Without fertilization the female oviposited but in all cases observed, according to W. G. Bradley at the U. S. Entomological Laboratory, Arlington, Mass., the resulting progeny were exclusively males.

Confined females were found readily to attack young Pyrausta larvae placed before them and each oviposited a number of times within a short period. A female quickly detects the presence of a borer larva and approaches until she can sense it with her antennal tips. She then jumps upon it and clinging with her feet, arches her abdomen, brings the ovipositor forward, and by a rapid thrust inserts it into the squirming host to lay an egg. No paralyzation of the host larva occurs and the female apparently exercises little or no choice as to the part of the larva's body in which an egg is to be deposited.

Oviposition requires only a few seconds and a female was observed to oviposit in several larvae within a short time, and sometimes more than once in the same larva. Normally only one egg is deposited at a single thrust of the ovipositor. More than one egg placed within a host larva was superfluous, as the resulting larvae were killed, and usually only a single individual issued.

Borer larvae of the second to fourth instar, according to Thompson and Parker (*11*), are chosen by the female for

oviposition and Jones (*6*) found that host larvae in the second instar were preferred to all others.

The egg, under normal conditions, hatches in from two to three days and the young larva passes through three distinct stages within the host before issuing to spin its cocoon. From available data it seems likely that the first stage of the Microgaster larva in the field, during late July and early August, is of approximately 15 to 20 days' duration. The second stage lasts about a week and the third a couple of days only.

The last-stage larva of Microgaster, after issuing, feeds externally on the host for a short time before constructing the cocoon within which it pupates and transforms to the adult. In the first generation in northern France and in the second in Italy the prepupa which develops in the autumn remains for some months before further visible changes take place, and actual pupation and adult emergence follow in the spring. On the other hand, the prepupal period in individuals of the first generation, in the Po valley of Italy, is of short duration and pupation and adult emergence follow within the next few weeks of summer weather.

The time required to obtain adult emergence from overwintering prepupal larvae from northern France within their cocoons depends partly upon the temperature. This fact has been demonstrated by accumulated data summarized in Table II.

Although no extensive experiments have been undertaken to prove this point, it is probably true that overwintering prepupal larvae are undergoing certain slow physiological changes, and that the more advanced in such development the prepupae have become, the more quickly do they respond to temperatures which speed up the process of pupation and adult transformation. This reasoning would seem to account for the difference observed in those cocoons subjected to a temperature of 27° C. on January 17, and in others placed at 28° C. on February 24, adults of the former emerging in an average of 24.8 days and from the latter in 14.7 days. Low temperatures are known to retard the development of Microgaster.

## SEASONAL HISTORY.

In northern France, the parasite *Microgaster tibialis*, like its host, the corn borer, has only one generation annually, but two generations of the host and its parasite occur annually in

the Po Valley of Italy. In the former region the period of maximum emergence from the overwintering cocoons occurs between April 20 and May 20. However, data collected by field assistants, from 1925 to 1929, show that in certain years the time of emergence varies. For instance, in 1925, adults of Microgaster started to emerge as early as March 12 and the peak of emergence took place between April 16 and 23; adults were in the field on April 5 in 1926, and on April 7 in 1927, although the heaviest emergence occurred at about the normal time in both years.

Unless the adults, emerging in April and May, avail themselves of an intermediate host, they must wait a considerable length of time before young larvae of Pyrausta appear in the

TABLE II.

Period Elapsing Before Adult Emergence, From Overwintering Prepupal Larvae, of *Microgaster tibialis* at Various Temperatures, Hyères, Var, France.

| Temperature Condition | Date Placed Under Observation | Number of Individuals | Period Elapsing Before Adult Emergence | | |
|---|---|---|---|---|---|
| | | | Average Number of Days | Maximum Number of Days | Minimum Number of Days |
| 18° C..... | Jan. 17, 1927..... | 109 | 39.6 | 62 | 28 |
| 27° C..... | Jan. 17, 1927..... | 95 | 24.8 | 40 | 16 |
| 28° C..... | Feb. 24, 1929..... | 24 | 14.7 | 24 | 8 |
| Outdoor insectary. | Jan.17–Feb.1,1927 | 92 | 82.4 | 95 | 63 |

field. However, the ability of Microgaster to live for several months, under certain conditions, would permit the parasite to undergo such a wait for the advent of available larvae. On the other hand, the known polyphagous habits of the parasite support the idea that it may use an intermediate host. In any event, adults of the parasite are in the field to oviposit in Pyrausta larvae of the early instars, as first-stage larvae of Microgaster have been found within young host larvae collected on July 27 and later. In the course of dissections of over 1,000 host larvae, of the first to fourth instars, collected after August 1, only young larvae of the parasite have been observed. It is, therefore, probable that the deposition of eggs takes place in July.

In 1928 and 1929 the first specimens of second-stage larvae of this parasite were found in third instar hosts collected in

Lille on August 9. On August 27 and thereafter, fourth instar borers were observed to contain both first and second stage Microgaster, with the number of the latter stage on the increase. On September 3, 1929, 40 per cent of the Microgaster larvae, in fourth instar hosts, were in their second stage, and on September 7, third stage parasite larvae were also present. In 1925, in the Vosgian zone, second-stage Microgaster larvae were found on August 28 and on September 7.

Undoubtedly the third stage of the Microgaster larva is of only a few days' duration. On September 23, 1926, in northern France, the third-stage larvae were issuing from the host and spinning their cocoons. Cocoon formation that year continued until the middle of October.

Near Bergamo, Italy, where two generations of both host and parasite occur, the adults of Microgaster emerging in the spring (or in early summer if an intermediate host exists in that region) deposit their eggs in young borer larvae in June and early July and in the heat of midsummer the parasite larvae develop rapidly. Both first and second stage parasite larvae were found in hosts collected on July 20, 1925; on July 21 larvae of all three stages and a cocoon of this species were present. A collection of 22 Microgasters, made on July 23, gave the following: ten first-stage larvae, eight second-stage larvae, one third-stage larva, and three fresh cocoons. Evidently, most of the cocoons are formed during late July, thus allowing the emergence of adults to start in early August. In 1925, 28 per cent of the cocoons were empty by August 4, over 50 per cent on August 13, and 82 per cent on August 17. By this time young Pyrausta larvae of the second generation were in the field to receive the eggs of Microgaster, from which larvae developed and issued to spin their overwintering cocoons in October.

## HYPERPARASITES.

A number of hyperparasites are known to attack *M. tibialis* in Europe and the following list is no doubt incomplete:

*Gelis fraudulentus* Först. (Det. Cushman), *G. instabilis* Först. (Det. Roman and Cushman), *G. acarorum* L. (Det. Roman), *Stictopisthus laticeps* Thoms. (Det. Roman and Cushman), and *Mesochorus tuberculiger* Thoms. (Det. Cushman) have been reared from Microgaster cocoons collected in the north of France. Another hyperparasite from the same

region was tentatively determined by Roman as *Epiurus brevicornis* Gr., and it is probable that *Hemiteles* sp. and other species of *Mesochorus* attack Microgaster.

## SUMMARY.

*Microgaster tibialis* Nees, considered as one of the more efficient parasites of *Pyrausta nubilalis* Hübn. in Europe, is a solitary braconid which attacks the young stages of the host larva. The female deposits her egg within the body cavity of the small borer and the parasite larva passes three stages internally before issuing to spin a cocoon.

The species, although generally distributed in Europe, has been found of greatest economic importance as a parasite of Pyrausta in the one-generation area of northern France. The average parasitism for the eight-year period (1922–1929, inclusive) in the region of Paris, was 29.7 per cent, with maximums of 63.2 and 52.5 per cent in 1925 and 1926, respectively, and for a six-year period (1924–1929, inclusive), in the environs of Lille, the average parasitism by Microgaster equalled 16.4 per cent. In the two-generation area of the host in the Po Valley of Italy the average parasitism of the first generation of Pyrausta near Bergamo for the seven-year period (1924–1930, inclusive) was 5.7 per cent. In these and other localities where studies have been made the degree of control by *M. tibialis* has shown considerable fluctuation.

This parasite has been collected in large numbers from European areas and shipments containing a total of 587,062 cocoons, have been made to the United States over the period from 1923 to 1930, inclusive.

This Microgaster overwinters as a prepupa within its cocoon. In the one-generation area of Pyrausta in northern France the adult emerges in April and May and deposits its eggs about July. The spinning of the cocoon takes place in October. In the Po Valley of Italy, where two generations of the host occur, two broods of the parasite develop on Pyrausta.

Certain morphological characters distinguish the adult and immature stages of *M. tibialis* from other parasitic Hymenoptera. Among the postembryonic forms, the head of the last-stage larva provides a number of distinctive characters of value in a determination of the species.

A number of hyperparasites have been found attacking *M. tibialis* in Europe.

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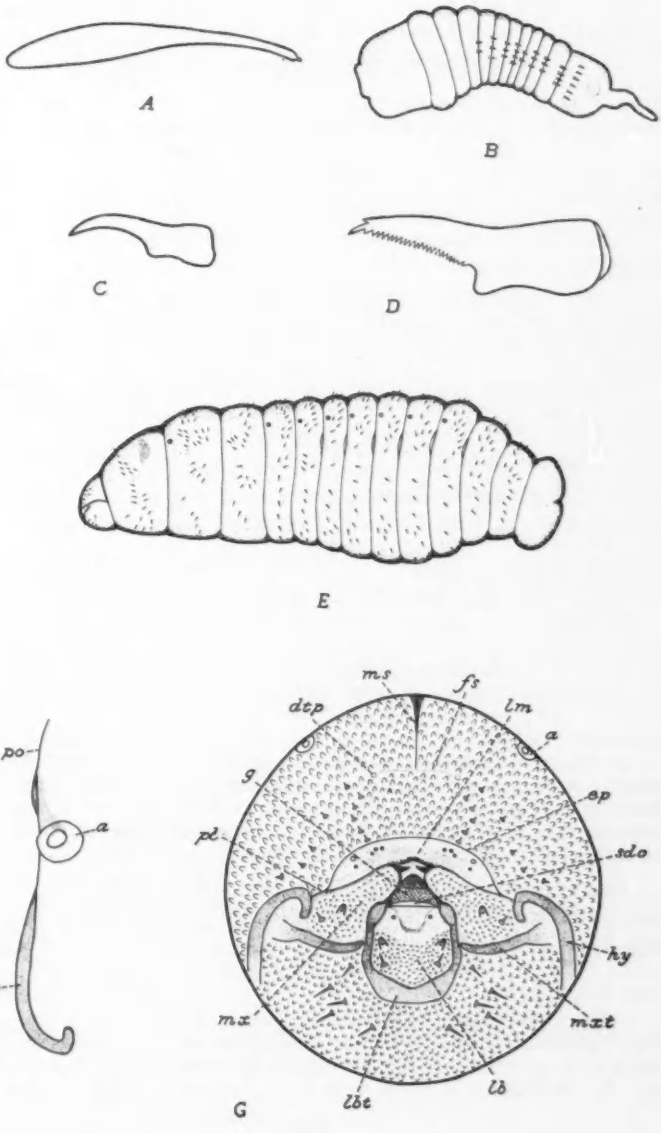
## EXPLANATION OF PLATE.

Fig. A. Egg, immediately after oviposition.
Fig. B. First-stage larva, few days old, dorsal view.
Fig. C. Mandible of first-stage larva.
Fig. D. Mandible of last-stage larva.
Fig. E. Prepupa removed from hibernating cocoon, lateral view.
Fig. F. Right half of postocciput and one antenna, lateral view.
Fig. G. Head of last-stage larva, front view.

## LIST OF ABBREVIATIONS.

*a*.....antenna.
*dtp*.....dorsal tentorial pit.
*ep*.....epistoma.
*fs*.....frontal suture.
*g*.....glossa (anterior part of hypopharynx).
*hy*.....hypostoma.
*lb*.....labium.
*lbt*.....labial thickening.
*lm*.....labrum.
*ms*.....metopic suture.
*mx*.....maxilla.
*mxt*.....maxillary thickening.
*pl*.....pleurostoma.
*po*.....postocciput.
*sdo*.....orifice of silk duct.


A
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# SIX NEW APHIDS FROM COLORADO

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## **Toxoptera viridi-rubra,** n. sp.

(Plate A, Figs. 1 and 2; Plate B, Fig. 1.)

*Fundatrix.*

Color: Reddish-brown or mahogany mottled with paler color; cauda slightly dusky; cornicles black; legs pale except femora; tips of tibiae and entire tarsi which are dusky to black; antennae dusky throughout.

Measurements: Body, 2.10 mm.; hind tibiae, .66 mm.; hind tarsi, .09 mm.; antennae, 1.10 mm.; III + IV (anastomosed), .42 mm.; V, .16 mm.; VI, .11 + .25 mm.; cornicles, .25 mm.

Structural Characters: As in apterous summer vivipara.

Described from morphotype specimen taken on *Carex nebraskensis*, at Fort Collins, Colorado, April 26, 1915.

*Apterous summer vivipara.*

Color: Not observed before specimens were mounted in balsam.

Measurements: Body, 2 mm. by 1.25 mm.; hind tibiae, .80 mm.; hind tarsi, .09 mm.; antennae, 1.35 mm.; III, .30 to .33 mm.; IV, .17 to .25 mm.; V, .11 to .19 mm.; VI, .09 + .40 to .45 mm.; cornicles, .25 to .30 mm.; cauda, .09 mm. hard portion, .12 mm. entire length; rostrum rather broadly obtuse, joint IV + V, .09 mm., attaining 2nd coxae.

Structural Characters: As in alate vivipara except the following: Frontal tubercles each bearing a rudimentary finger-like projection. Secondary sensoria absent on antennae. Hairs on vertex, .04 mm. long; on frontal tubercle, .03 mm.; on outer side of hind tibiae, .07 to .10 mm.; twice diameter of tibia in length.

Described from morphotype specimens taken on *Carex nebraskensis* at Fort Collins, November 9, 1914, May 17, 1915 and May 12, 1915.

*Alate vivipara.*

Color: Olive-green with dusky lateral areas and orange stain about cornicle bases and across dorsum of 6th abdominal segment; cauda pale; cornicles black; legs pale yellow with femora mostly dusky and tips of tibiae and entire tarsi black; antennae dusky throughout.

Measurements: Body, 1.70 mm. (1.1 to 2 mm.); hind tibiae, .83 mm. (.77 to .90 mm.)*; hind tarsi, .09 mm.; antennae, 1.50 mm. (1.40 to 1.50 mm.); III, .37 mm. (.36 to .42 mm.); IV, .21 mm. (.20 to .25 mm.); V, .22 mm. (.21 to .23 mm.); VI, .10 + .46 mm. (.44 to .50 mm.); cornicles, .26 mm.; cauda, .08 mm. hard portion, .13 mm. entire length; rostrum rather broadly obtuse, joint IV + V, .09 mm. long, nearly attaining 2nd coxae.

Structural Characters: Vertex slightly convex. Frontal tubercles distinct mesally, exceeding vertex by .02 mm. Secondary sensoria circular, with narrow rims, flat, arranged in single row along almost entire length of joints, 10 on III on one antenna and 11 on the other (6 to 11), 3 and 5 on IV, 1 and 2 (0 to 2) on V. Hairs on vertex slightly capitate .02 to .025 mm. long; on antennae pointed, .015 mm. long; on outer side of hind tibiae pointed, .05 to .06 mm. long, 1.25 to 1.5 times diameter of tibia in length, rather longer than hairs on inner side; on cauda curved and .05 to .06 mm. long. Cornicles cylindrical with tendency to constriction next to distinct flange, imbricated, about same width as hind tibiae. Cauda blunt, cylindrical with slight constriction near base, spoon-shaped, bearing 2 pairs of lateral hairs and a single dorsal hair at tip. Lateral tubercles evident on prothorax and all abdominal segments except 5th and 8th. Ocular tubercles present. Fore wings with mediae once-branched; hind wings with both media and cubitus.

Described from holotype and 9 paratype specimens taken on *Carex nebraskensis*, at Fort Collins, May 12 and 17, 1915.

*Apterous ovipara.*

Color: Not observed before mounting in balsam.

Measurements: Same as apterous summer vivipara except cornicles .22 mm.

Structural Characters: Same as apterous summer vivipara except hind tibiae which are somewhat swollen in middle portion and rather thickly covered with nearly flat sensoria of irregular size on middle half.

Male: Described from allotypes taken along with the oviparae above-described and one Nov. 23 on same host and at same locality.

Color: Not observed before mounting.

Measurements: Same as alate vivipara, except cornicles .21 mm. long and slightly thinner than hind tibiae.

Structural Characters: Same as alate vivipara except the secondary sensoria which are small and rather thickly covering posterior side of antennal III, IV and V.

Described from morphotypes taken on *Carex nebraskensis*, at Fort Collins, November 9 to 13, 1914.

*Figures in parentheses indicate paratypes.

Collections: As mentioned under descriptions, and also a collection of under-sized examples of alate and apterous vivipara taken July 3, 1910 on same host and at same locality as types; 4 collections; apparently not common.

Types in collection of U. S. Nat. Mus., Cat. No. 43847; paratypes and morphotypes in collection of Colo. Agr. Exp. Sta.

Taxonomy: This species differs from *Toxoptera graminum* Rondani in darker green and reddish color of body, spoon-shaped cauda with more conspicuous hairs, and cornicles black and more robust, slightly wider than tibiae and longer hairs on outer side of hind tibiae. This species also differs from *Toxoptera caricis* Fullaway in the shape of cornicles which are much shorter and more cylindrical, unguis longer than III and spoon-shaped cauda. It differs from *Tox. nigra* Baker in body not being black; and in longer III which is never shorter than .75 of unguis and always longer than cornicle, even in apterae.

**Rhopalosiphum scirpifolii,** n. sp.

(Plate A, Figs. 4, 5 and 6; Plate B, Fig. 2.)

*Alate vivipara.*

Color: Black or greenish-black on entire dorsum; cornicles black; antennae, legs and cauda dusky.

Measurements: Body, 1.90 mm. (1.8 to 2 mm.); hind tibiae, 1.05 mm. (.90 to 1.10 mm.); hind tarsi, .12 mm.; antennae, 1.40 mm. (1.20 to 1.65 mm.); III, .38 mm. (.35 to .50 mm.); IV, .23 mm. (.22 to .29 mm.); V, .21 mm. (.18 to .29 mm.); VI, .10 + .35 mm. (.32 to .42 mm.); cornicles, .15 mm. (.14 to .17 mm.); cauda, .06 mm. hard portion, .12 mm. entire length; rostrum obtuse, joint IV + V, .12 mm., nearly attaining 2nd coxae.

Structural Characters: Vertex slightly convex. Frontal tubercles equalling vertex. Secondary sensoria round with narrow rims, 20 (18 to 24) in irregular double row along entire length of III, 8 (5 to 10) on IV, 2 (0 to 5) on V. Hairs pointed, on vertex .03 mm. long; on antennae and outside of hind tibiae .02 mm., sparse; on cauda, .04 to .05 mm. and curved, bushy. Cauda spoon-shaped, or short-cylindrical with slight neck, bearing 2 pairs of lateral hairs and a single dorsal one at tip. Cornicles slightly clavate, with suggestion of constriction just before broad flange, slightly imbricated. Lateral tubercles small but present on prothorax and abdominal segments 1 and 7. Fore wings with 2nd fork of media between one-fourth and one-third the distance from margin of wing to 1st fork.

Described from holotype and 1 paratype taken on *Scirpus* sp., at Fort Collins, Colo., Oct. 26, 1914, also numerous paratypes taken Oct. 15, 1914 on same host and locality.

*Apterous summer vivipara.*

Color: Very dark, nearly black on abdomen; thorax, head and lateral margins cinnamon-brown; slightly powdery, giving slaty color; legs yellowish with femora dusky and tips of tibiae and entire tarsi black; antennae dusky to blackish, joint III yellowish; cornicles yellowish with distal half black; cauda concolorous with body. Immature examples dark olive-green. Half-grown nymphs rather light green with an orange stain between cornicles.

Measurements: Body, 2 to 2.25 mm.; hind tibiae .80 to 1.00 mm.; hind tarsi, .12 mm.; antennae, 1.10 mm.; III, .24 to .41 mm.; IV, .13 to .24 mm.; V, .13 to .24 mm.; VI, .10 + .27 to .39 mm.; cornicles, .16 to .18 mm.; cauda, .08 mm. hard portion, .12 mm. entire length; rostrum attaining or slightly surpassing 2nd coxae.

Structural Characters: Same as alate vivipara, except secondary sensoria which are absent on antennae.

Described from morphotypes taken with alate vivipara paratypes, also with same data, Sept. 26, 1908 and Oct. 29, 1914.

*Apterous ovipara.*

Color: Olive-green to dark brown, lighter anteriorly and posteriorly; large orange spots at bases of cornicles; legs pale brownish with tips of tibiae and entire tarsi black; cornicles and cauda dusky. Eggs orange-yellow when first laid, turning black later.

Measurements: Body, 1.50 mm.; hind tibiae, .50 mm.; antennae, .65 to .70 mm.; III + IV, anastomosed, .25 mm.; V, .10 to .12 mm.; VI, .07 + .20 to .24 mm.; cornicles, .10 mm.

Structural Characters: Same as apterous summer vivipara except hind tibiae which are distinctly swollen along .75 of length and rather thickly covered with rather large, flat sensoria.

Described from morphotypes taken on *Prunus Besseyi* at Fort Collins, November 4, 1914.

*Alate male.*

Color: Same as alate vivipara.

Measurements: Body, 1.30 to 1.50 mm.; cornicles, .12 mm.; other measurements same as alate vivipara.

Structural Characters: Same as alate vivipara except that secondary sensoria are rather thickly scattered over antennal III, IV and V.

Described from allotypes taken on *Scirpus* sp., at Fort Collins, Oct. 7 and 15, and Nov. 2, 1914.

Collections: On leaves and stems of *Prunus Besseyi* as winter hosts where oviparae and alate sexuparae and alate males are found; on leaves and stems of *Scirpus* sp. as summer host where apterous and alate viviparae develope; as well as

fall migrants and alate males which fly back to the winter host.

*Apterous summer viviparae.*—Five collections, August 18 to October 30.
*Alate viviparae.*—Eight collections, April 13 to October 26.
*Apterous oviparae.*—Two collections, November 4 to 13.
*Alate males.*—Six collections, October 7 to November 13.

Thirteen collections in all; quite common and abundant on *Scirpus* sp. in the fall.

Types in collection of U. S. Nat. Mus., Cat. No. 43848; paratypes in collection of Colo. Agr. Exp. Sta.

Taxonomy: This species is very close to *Rhopalosiphum prunifoliae* Fitch but differs in the cornicles being shorter than antennal IV and with less pronounced flanges, and cauda shorter than base of antennal VI. In *Rhop. prunifoliae* cornicles are subequal or longer than antennal IV and cauda is longer than base of antennal VI. The hosts also differ as our species has not been found colonizing on other species of *Prunus* nor on any other summer host than *Scirpus* sp. Acknowledgments are due to F. C. Hottes and D. R. H. Lambers for aid in determination of this species.

**Aphis argentinae-radicis,** n. sp.
(Plate A, Fig. 9; Plate B, Fig. 3.)

*Apterous summer vivipara.*

Color: Dorsum pale greenish with mottling of darker green; dusky on head and bands on abdominal segments 7 and 8, speckles over remainder of dorsum and heaviest on pronotum; cornicles, anal plate, cauda, entire legs and antennae blackish. Young individuals, paler, dusky only on head and tips of joints of antennae and legs.

Measurements: Body, 1.70 mm. (1.4 to 1.7 mm.); hind tibiae, .90 mm.; hind tarsi, .12 mm.; antennae, 1.05 mm. (.75 to 1.05 mm.); III, .34 mm. (.23 to .34 mm.); IV, .21 mm. (.13 to .21 mm.); V, .15 mm. (.12 to .15 mm.); VI, 10 + .17 mm. (.13 to .17 mm.); cornicles, .08 mm.; cauda, .04 mm. hard portion, .08 mm. entire length; rostrum obtuse joint, IV + V, .16 mm. long, attaining abdomen.

Structural Characters: Vertex slightly convex. Frontal tubercles not equalling vertex. Secondary sensoria circular with broad rims, strongly convex and set on tubercles, 14 (2 to 14) scattered along distal ¾ mostly on distal ½ of III, 15 (1–15) along entire length of IV, 7 (1–7) on V. Hairs fine, pointed, erect, numerous, .04 to .05 mm. long on vertex, antennae, body and tibiae, equalling diameter of tibiae in length. Body surface not reticulated, finely setulose but not arranged in a pattern. Cornicles tapering, one and one-half times as wide at base as at tip, imbrications finely setulose, flange rather large. Cauda apparently rounded but with upturned tip as in genus *Cinara*, not

longer than broad, bearing 2 pairs of lateral and one pair of apical hairs. Lateral tubercles present.

Described from holotype and 12 paratypes taken on root of *Argentina anserina*, in Pingree Park, Colorado, Aug. 23, 1930.

*Apterous ovipara.*

Measurements: Body, 1.50 mm.; hind tibiae, .63 mm.; hind tarsi, .12 mm.; antennae, .68 mm.; III, .16 mm.; IV, .12 mm.; V, .10 mm.; VI, .10 + .12 mm.; cornicles, .07 mm.; cauda, .03 mm. hard portion, .07 mm. entire length.

Structural Characters: Same as apterous vivipara except secondary sensoria on antennae not evident and hind tibiae bearing about 2 sensoria near the middle, not causing noticeable swelling.

Described from morphotype taken with apterous vivipara described above.

No collections taken besides the one above mentioned.

Types in U. S. Nat. Mus., Cat. No. 43844; paratypes in collection of Colo. Agr. Exp. Sta.

Taxonomy: This species differs from *Aphis middletonii* in having conspicuous erect hairs, setulose cornicles, pronounced flanges on cornicles, only 2 or 3 pairs of hairs on cauda instead of 6 or 7, secondary sensoria conspicuously tuberculate, cornicles shorter and more tapering and unguis shorter, rarely longer, than half of III, and lack of powder or reticulation on body integument, also a much smaller number of sensoria on tibiae of oviparae.

**Aphis pilosicauda,** n. sp.

(Plate A, Fig. 3; Plate B, Fig. 4.)

*Alate vivipara.*

Color: Dorsum of head and thorax black; abdomen olive-green, with dusky lateral areas; cauda and cornicles blackish; legs dusky with femora, tips of tibiae and entire tarsi black.

Measurements: Body, 1.90 mm. (1.50 to 1.90 mm.); hind tibiae, .80 mm. (.65 to .80 mm.); hind tarsi, .11 mm.; antennae, 1.05 mm. (.80 to 1.05 mm.); III, .22 mm. (.19 to .22 mm.); IV, .12 mm. (.11 to .12 mm.); V, .13 mm. (.11 to .13 mm.); VI, .11 + .35 mm. (.28 to .35 mm.); cornicles, .25 mm. (.22 to .25 mm.); cauda, .08 mm. on median line of hard portion, .12 mm. entire length; rostrum rather slender, obtuse, joint IV + V, .18 mm. long, attaining 1st segment of abdomen.

Structural Characters: Vertex slightly convex. Frontal tubercles rudimentary, not equalling vertex. Secondary sensoria circular, flat, with narrow rims, arranged in single row along almost entire length of antennal III, 6 or 7 in number; absent on IV and V. Hairs pointed,

fine, sparse, .01 mm. long on vertex, antennae and outer side of hind tibiae, on cauda fine, curved, .05 mm. long. Cornicles cylindrical, rather slender, about same width as hind tibiae, inbricated and with flanges. Cauda blunt, conical to cylindrical, slightly longer than wide, bearing about 8 hairs on each side. Lateral tubercles on prothorax and abdominal segments 1 and 7. Fore wings with 2nd fork of media one-third or slightly more of the distance from margin of wing to 1st fork.

Described from holotype and 3 paratypes taken on *Cirsium* sp. at ground line, at Fort Collins, June 3, 1918, other paratypes taken June 23, 1912, and July 7, 1917.

*Apterous summer vivipara.*

Color: Dorsum olive-green, covered with slight powder; cauda and cornicles dusky to blackish; legs yellowish with tips of tibiae and entire tarsi black.

Measurements: Same as in alate vivipara except cornicles .25 to .30 mm. and rostrum attaining 2nd or 3rd abdominal segment.

Structural Characters: Same as in alate vivipara except, secondary sensoria absent. Dorsal integument reticulated.

Described from morphotypes taken with alate vivipara described above.

*Apterous ovipara.*

Color: Dorsum olive-green, lighter on middle of abdomen due to yellow eggs showing through; cauda and cornicles black; legs pale yellow except, femora brownish and tips of tibiae and entire tarsi black.

Measurements: Body, 1.80 mm.; hind tibiae, .53 to .60 mm.; hind tarsi, .10 mm.; antennae, .80 mm.; III, .14 to .16 mm.; IV, .09 mm. (III and IV nearly anastomosed); V, .11 mm.; VI, .10 + .24 mm.; cornicles, .20 to .23 mm.; cauda, .06 mm. hard portion, .10 mm. entire length; rostrum as in vivipara.

Structural Characters: Same as apterous vivipara except hind tibiae which bear a few hardly visible sensoria, perhaps 1 to 4, on inner side of middle portion, causing a very slight swelling.

Described from morphotypes taken Oct. 22 to 30, 1916.

*Apterous male.*

Color: Dorsum of head brownish; abdomen olive-green; cauda and cornicles blackish; legs yellowish with tips of tibiae and entire tarsi black.

Measurements: Body, 1.20 mm.; hind tibiae, .53 mm.; hind tarsi, .10 mm.; antennae, .70 to .75 mm.; III, .16 mm.; IV, .10 mm. (III + IV sometimes anastomosed and .22 mm.) V, .11 mm.; VI, .09 + .20 mm.;

cornicles, .15 mm.; rostrum with joint IV + V, .12 mm. long, attaining middle of abdomen.

Structural Characters: Same as apterous viviparae described above except secondary sensoria thinly scattered over antennal joints III, IV and V.

Described from allotypes taken with morphotype oviparae described above.

Collections: On *Cirsium* sp. on stem near roots or on roots, near Fort Collins and Boulder, Colo., by L. C. Bragg and the writers, as follows:

*Apterous summer viviparae.*—Seven collections, June 19 to September 18.
*Alate viviparae.*—Four collections, June 11 to July 7.
*Apterous oviparae.*—Three collections, October 4 to 30.
*Apterous males.*—One collection, October 30, 1916.

Types in U. S. Nat. Mus., Cat. No. 43845; paratypes in collection of Colo. Agr. Exp. Sta.

Taxonomy: This species is distinguished from *Aphis cardui* Linn. by fewer sensoria, much more numerous hairs on cauda, much shorter antennae and lack of dusky dorsal bands. From *A. carduella* Walsh, it is distinguished by fewer sensoria and conical cauda without constriction.

Acknowledgments are due to F. C. Hottes for aid in determining this form.

**Aphis pseudovalerianae,** n. sp.

(Plate A, Figs. 7 and 8; Plate B, Fig. 5.)

*Alate vivipara.*

Color: Head and thorax brown to black, abdomen light olive-green, with dusky lateral areas and band on 7th and 8th abdominal segments; cauda, cornicles, antennae and legs brown to black.

Measurements: Body to base of cauda, 1.50 mm. (1.5 to 1.8 mm.); hind tibiae, .80 mm.; hind tarsi, .12 mm.; antennae, 1.05 mm.; (1.05 to 1.30 mm.); III, .30 mm. (.25 to .32 mm.); IV, .19 mm. (.17 to .20 mm.); V, .19 mm. (.19 to .20 mm.); VI, .13 + .23 mm. (.22 to .25 mm.); cornicles, .18 mm. (.16 to .18 mm.); cauda, .08 mm. hard portion, .14 mm. entire length; rostrum obtuse, joint IV + V, .13 mm. long, attaining 3rd coxae.

Structural Characters: Secondary sensoria circular, rather small, slightly convex, hardly tuberculate, scattered along entire length of joints, 15 (14 to 20) on III, 3 and 5 (3 to 7) on IV, 1 and 3 (1 to 5) on V. Hairs pointed, numerous, erect; on vertex and antennae and outer side of tibiae .03 to .05 mm. long. Cornicles cylindrical, with flanges, imbricated, bearing 2 to 4 hairs on proximal half. Cauda cylindrical, broad and obtuse, bearing about 5 hairs on each side. Lateral tubercles present, large on pronotum and abdominal segments 1 and 7. Fore

wings with 2nd fork of media between one-third and one-half the distance from margin of wing to 1st fork.

Described from holotype and paratype taken on *Valeriana* sp. at Log Cabin, Colorado, July 11, 1919; other paratypes July 25, 1917 and Aug. 2, 1917.

*Apterous summer vivipara.*

Color: Head brown; thorax dusky green; abdomen light olive-green, with slightly dusky lateral areas, and dashes on dorsum of abdominal segments 7 and 8; cauda and cornicles black; legs brown tips of tibiae and entire tarsi black; antennae brown to black.

Measurements: Same as alate vivipara except, rostrum attains 1st segment of abdomen.

Structural Characters: Same as alate vivipara except, secondary sensoria are absent on antennae.

Described from morphotypes taken with alate viviparae described above.

*Apterous ovipara.*

Color: Head and prothorax brownish, abdomen yellowish olive-green; cauda and cornicles dusky; legs pale except, femora dusky and tips of tibiae and entire tarsi black.

Measurements: Body, 1.50 mm.; hind tibiae, .75 mm.; hind tarsi, .12 mm.; antennae, .85 mm.; III, .20 mm.; IV, .12 mm.; V, .14 mm.; VI, .10 + .19 mm.; cornicles, .13 mm.

Structural Characters: Same as in apterous vivipara except, hind tibiae very slightly swollen and bearing 2 or 3 irregular-sized faint sensoria.

Described from morphotypes taken on *Valeriana* sp. at Fort Collins, Sept. 7 and 10, 1917.

Collections: On *Valeriana* sp., one record on roots, at Log Cabin and one at Fort Collins, both by L. C. Bragg.

*Apterous summer vivipara.*—Three collections, July 11 to August 2.
*Alate vivipara.*—Three collections, July 11 to August 2.
*Apterous ovipara.*—Two collections, September 7 and 10.

Five collections in all, apparently rare.

Types in U. S. Nat. Mus., Cat. No. 43843; paratypes in collection of Colo. Agr. Exp. Sta.

Taxonomy: This species is very close to *Aphis valerianae* Cowen but differs in the longer erect hairs, presence of hairs on cornicles, light color, shorter antennal joints and cornicles and sensoria not tuberculate.

**Pseudoepameibaphis,** n. g.

Characters: Vertex nearly flat. Frontal tubercles absent. Ocular tubercles rudimentary. Hairs blunt or with fan-shaped tips. Cornicles slender, impinged against abdomen, slightly swollen distally on inner side, with thin-edged flange set obliquely. Cauda conical. Lateral tubercles not evident. Wing venation as in *Aphis*.

This genus differs from *Epameibaphis* Oestlund (19th. Rept. St. Ent. Minn., p. 132, 1922), in the strikingly different shape of cornicles.

Genotype **Pseudoepameibaphis glauca,** n. sp.
(Plate A, Figs. 10, 11 and 12; Plate B, Fig. 6.)

*Alate vivipara.*

Color: Dorsum of head and thorax medium brown, abdomen glaucous-green; slightly powdery throughout; cauda pale; cornicles pale with dusky tips; legs pale with tips of tibiae and entire tarsi black; veins of wings brown, rather heavy.

Measurements: Body, 1.20 mm. (1.2 to 1.5 mm.); hind tibiae, .75 mm. (.70 to .75 mm.); hind tarsi, .12 mm.; antennae, 1.40 mm.; III, .30 mm. (.27 to .30 mm.); IV, .27 mm. (.22 to .27 mm.); V, .22 mm. (.18 to .23 mm.); VI, .14 + .40 mm. (.37 to .40 mm.); cornicles, .20 mm.; cauda, .08 mm. hard portion, .12 mm. entire length; rostrum slender acute, joint IV + V .12 mm.; portion beyond hairs slender and needle-like in ventral aspect, .06 mm. long, resembling distinct 5th joint, attaining 2nd coxae.

Structural Characters: Vertex flat. Frontal tubercles lacking. Secondary sensoria circular, flat, scattered along entire length of III, 9 (5 to 9) in number; on IV, 0 (0 to 1). Hairs slightly capitate; on vertex .04 mm. long; on antennae, .015 to .02 mm., very sparse and inconspicuous; on middle of hind tibiae, .03 mm. to .04 mm., rather numerous, drooping. Cornicles slender, not as wide as hind tibiae, slightly swollen on inner side of distal one-third; flange distinct and thin-rimmed, oblique. Cauda conical bearing two pairs of lateral hairs and a single dorsal one. Lateral tubercles and ocular tubercles not evident. Fore wings with media twice forked; hind wings with both media and cubitus. Tibiae with terminal pad not evident.

Described from holotype and 2 paratypes taken on *Artemisia frigida*, in Poudre Canon, Colorado, May 23, 1922; 3 paratypes from same host near Fort Collins, Colorado, June 2, 1915, and April 15, 1919.

*Apterous summer vivipara.*

Color: Entire dorsum glaucous-green, covered with slight powder; appendages as in alate vivipara.

Measurements: Body, 1.20 mm.; hind tibiae, .55 to .60 mm.; hind tarsi, .11 mm.; antennae, 1 to 1.1 mm.; III, .16 to .25 mm.; IV, .16 to .24 mm.; V, .15 to .19 mm.; VI, .11 to .13 + .31 to .42 mm.; cornicles, .19 to .23 mm.; cauda ,.10 mm. hard portion; rostrum as in alate vivipara described above, except attaining 3rd coxae.

Structural Characters: Vertex slightly convex. Secondary sensoria absent on antennae. Hairs slightly capitate to fan-like, on vertex; hind tibiae and body .05 mm. long, conspicuous; cauda and cornicles as in alate vivipara.

Described from one morphotype taken with holotypes and 3 morphotypes taken on same host, at Fort Collins, Mar. 20, 1916.

*Apterous ovipara.*

Color: Entire dorsum olive-green to brown, lighter on middle of abdomen due to yellow eggs within; cornicles pale with blackish tips; cauda, antennae and legs brownish, with tips of tibiae and entire tarsi black and swollen, basal third of hind tibiae dusky.

Measurements: Body, 1.2 to 1.5 mm.; hind tibiae, .63 mm.; hind tarsi, .11 mm.; antennae, 1 to 1.1 mm.; III, .21 mm.; IV, .18 to .21 mm.; V, .17 mm.; VI, .10 to .12 + .31 to .35 mm.; cornicles, .18 to .20 mm.; cauda, .10 mm. hard portion, .12 mm. entire length.

Structural Characters: Same as in apterous vivipara except, hind tibiae somewhat swollen and darkened on basal third and bearing about 12 to 15 flat sensoria.

Described from 3 morphotypes taken on *Artemisia frigida*, at Fort Collins, Colorado, Nov. 11, 1916.

*Apterous male.*

Color: Entire dorsum brownish to greenish; cauda brownish; cornicles darker at tips; legs yellowish-brown with tips of tibiae and entire tarsi black; antennae blackish.

Measurements: Body, .80 mm.; hind tibiae, .72 mm.; hind tarsi, .12 mm.; antennae, 1.50 mm.; III, .27 to .35 mm.; IV, .25 to .30 mm.; V, .20 to .23 mm.; VI, .10 to .13 + .35 to .39 mm.; cornicles, .15 mm.; cauda, .05 mm. hard portion, .08 mm. entire length; rostrum attaining 3rd coxae.

Structural Characters: Same as apterous vivipara except, secondary sensoria rather thickly scattered along entire lengths of joints III, IV and V; vertex bearing a median ocellus as in alatae.

Described from morphotypes taken with oviparae described above.

Collections: On leaves and stems of *Artemisia frigida* about Fort Collins, LaPorte and Poudre Canon, Colorado, by L. C. Bragg and the writers.

*Apterous summer viviparae.*—Three collections, March 20 to October 12.
*Alate viviparae.*—Three collections, April 15 to June 2.
*Apterous oviparae.*—Five collections, October 30 to December 3.
*Apterous males.*—Four collections, November 6 to December 3.

Types in U. S. Nat. Mus., Cat. No. 43846; paratypes in collection of Colo. Agr. Exp. Sta.

Taxonomy: This species is closely allied to *Aphis tridentatæ* Wilson but differs from Wilson's description in longer antennae and cauda. It may prove on further study that Wilson's species is extraordinarily variable and our species may prove to be synonymous. A few specimens were taken on other species of *Artemisia* with longer cornicles but material is insufficient to determine their status at present.

## EXPLANATION OF PLATES.

### Plate A.

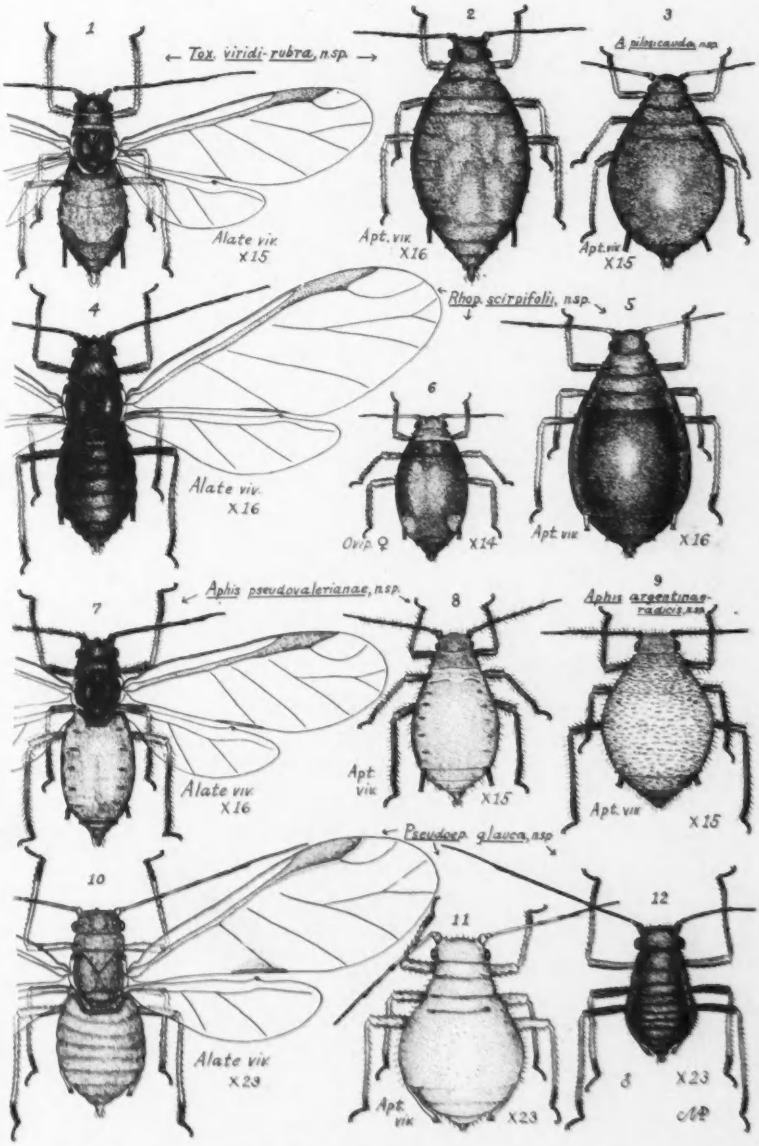
*Toxoptera viridi-rubra*, n. sp. 1, alate vivipara; 2, apterous vivipara.
*Aphis pilosicauda*, n. sp. 3, apterous vivipara.
*Rhopalosiphum scirpifolii*, n. sp. 4, alate vivipara; 5, apterous vivipara; 6, ovipara.
*Aphis pseudovalerianae*, n. sp. 7, alate vivipara; 8, apterous vivipara.
*Aphis argentinae-radicis*, n. sp. 9, apterous vivipara.
*Pseudoepameibaphis glauca*, n. sp. 10, alate vivipara; 11, apterous vivipara; 12, apterous male.

### Plate B.

Fig. 1. *Toxoptera viridi-rubra*, n. sp.
Fig. 2. *Rhopalosiphum scirpifolii*, n. sp.
Fig. 3. *Aphis argentinae-radicis*, n. sp.
Fig. 4. *Aphis pilosicauda*, n. sp.
Fig. 5. *Aphis pseudovalerianae*, n. sp.
Fig. 6. *Pseudoepameibaphis glauca*, n. sp.

## ABBREVIATIONS.

Ca.—cauda.
Co.—cornicle.
Fund.—fundatrix.
Int. or integ.—Integument.
R.—rostrum.
Ti.—hind tibia.
Vert.—vertex.


1
← Tox. viridi-rubra, n.sp. →
Alate vir.
X15
2
Apt. vir.
X16
3
A. pilosicauda, n.sp.
Apt. vir.
X15
4
Alate viv.
X16
← Rhop. scirpifolii, n.sp.
5
Apt. vir.
X16
6
Ovip. ♀
X14
7
← Aphis pseudovalerianae, n.sp.
Alate vir.
X16
8
Apt.
vir.
X15
9
Aphis argentinae-radicis, n.sp.
Apt. vir.
X15
← Pseudoph. glauca, n.sp.
10
Alate vir.
X23
11
Apt.
vir.
X23
12
♂
X23

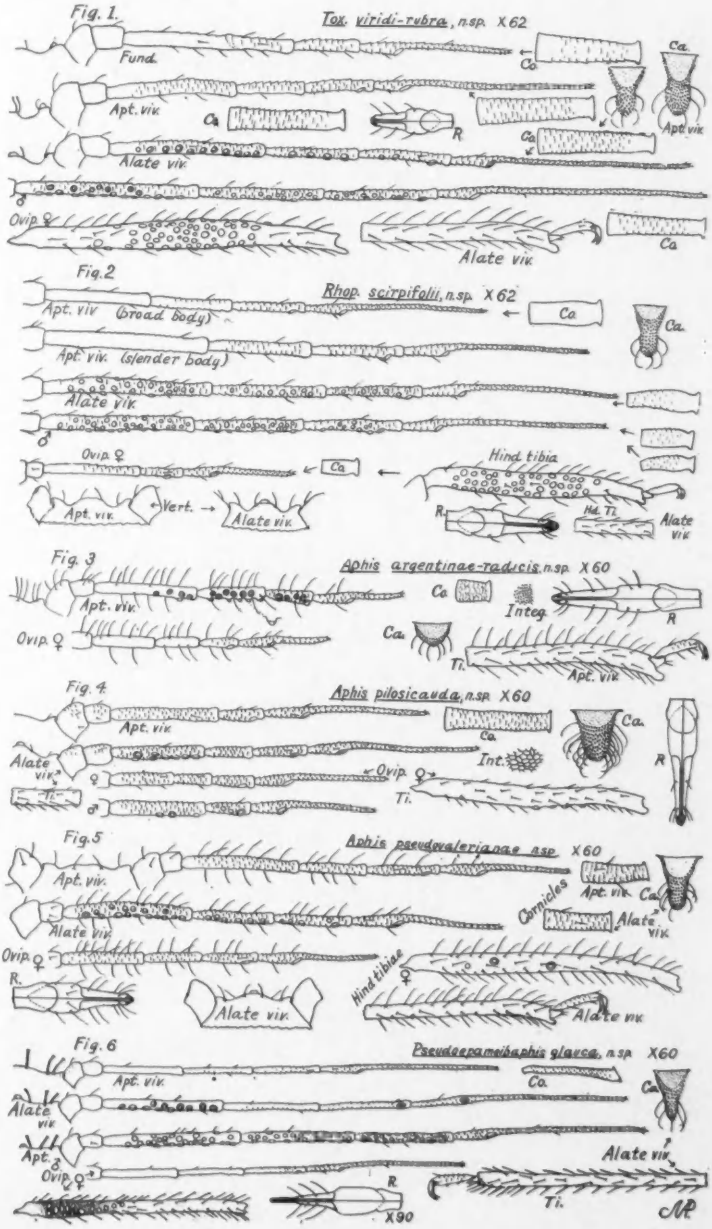


Fig. 1.
Tox. viridi-rubra, n.sp. X62
Fund.
Ca.
Apt. viv.
Alate viv.
Ovip. ♀
♂
R
Fig. 2
Rhop. scirpifolii, n.sp. X62
Apt. viv (broad body)
Apt. viv. (slender body)
Alate viv.
Ovip. ♀
Hind tibia
Vert.
Hd. Ti.
Fig. 3
Aphis argentinae-radicis n.sp. X60
Integ.
Ti.
Fig. 4
Aphis pilosicauda, n.sp. X60
Int.
Fig. 5
Aphis pseudovalerianae nsp. X60
Cornicles
Hind tibiae
Fig. 6
Pseudoparamyzaphis glauca, n.sp. X60
Apt.
X90
NP

# THE HYMENOPTEROUS FAMILY XYELIDÆ IN NORTH AMERICA.*

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The Xyelidæ are considered by most authors as comprising the most primitive family of the Hymenoptera, and there are many morphological arguments for upholding this viewpoint. The typical venation of the wings, the transverse pronotum, the sterno-pleural suture, and many other characters support the idea of its primitive relationships, but at the same time such characters as the modification of the third antennal segment, the development and structure of the maxillae, and the reduction of the male genital plates, show that in addition to being of great antiquity, the family has followed lines of variation and deviation very different from most of the other sawfly groups.

In this paper six genera are recognized, all of which occur in North America, and three of which occur in Eurasia. No forms are yet known from tropical regions or the Southern Hemisphere. It seems impractical to divide the family into subfamily or tribal units because of the conflicting nature of the structural differences between the genera. *Megaxyela* and *Macroxyela* appear to form a natural unit on the basis of all major characters, and *Xyela*, *Neoxyela* and *Pleroneura* appear closely related, having essentially similar maxillae and only one closed submarginal cell in the hind wing. *Xyelecia*, however, combines characters of both groups, having only one closed submarginal cell in the hind wing and having the galea lobed, and in addition has wing and antennal characters peculiar to itself. A dichotomous grouping of the genera on either the antennal filament or position of the subcostal veins is entirely unsatisfactory for it groups unrelated genera and separates those which seem most closely allied.

The biology of most of the species in the family is unknown. Dyar (1898) described the larvae and biology of three species.

*Contribution No. 148 of the Entomological Laboratories of the University of Illinois, Urbana, Ill.

Yuasa (1922) described the larvae of two more, one of them not reared, and keyed the five known larval forms.

The more important synonymy of the group name is as follows:

*Xyelinæ* Newman, Ent. Mag., Vol. 2, 1834, p. 379; Enslin, Deut. Ent. Zeit., Beiheft, 1912, p. 37.
*Xyelides* Westwood, Mod. Class. Ins., Vol. II, 1840, 114; Norton, Trans. Amer. Ent. Soc., Vol. II, 1868, p. 347.
*Xyelina* C. G. Thomson, Hym. Scand., Vol. I, 1871, p. 314.
*Xyelini* Konow, Ent. Nachr., Vol. 23, No. 4, Feb., 1897, p. 55; Genera Insectorum, 27th Fasc., 1905, p. 21.
*Xyelidæ* Ashmead, Psyche, Vol. 8, No. 265, May, 1898, p. 214; Can. Ent., Vol. XXX, No. 8, Aug., 1898, p. 205; Rohwer, Proc. Ent. Soc. Wash., Vol. XIII, 1911, p. 216; MacGillivray, Proc. U. S. Nat. Mus., Vol. XXIX, No. 1438, 1906, p. 621; Bull. 22, Conn. Geol. Nat. Hist. Surv., 1916, p. 29; Yuasa, Ill. Biol. Monographs, Vol. VII, No. 4, Oct., 1922, p. 39.

KEY TO THE GENERA OF THE FAMILY XYELIDÆ.

1. Vein $R_2$ present (Fig. 1) ..... 2
   Vein $R_2$ atrophied (Fig. 4) ..... **Neoxyela**
2. Subcosta fused with stem of R-M, or if slightly separated, then $Sc_2$ not evident (Fig. 2) ..... **Xyela**
   Subcosta free from stem of R-M, subcostal cell and $Sc_2$ distinct (Fig. 1) ..... 3
3. Hind wings with only one closed submarginal cell (Fig. 7); front wings (Fig. 1) with $Sc_2$ joining R before point of separation of M ..... 4
   Hind wings with two closed submarginal cells (Fig. 11); front wings (Figs. 5, 6) with $Sc_2$ joining R beyond point of separation of M ..... 5
4. Point of insertion of *m-cu* on M almost twice its own length basad of point of insertion of *r-m* (Fig. 1); apical thread of antenna with 20 or more segments together equal to length of third segment (Fig. 20); maxillary palpus 4-segmented (Fig. 12) ..... **Xyelecia**
   Point of insertion of *m-cu* on M interstitial with or slightly distad of *r-m* (Fig. 3); apical thread of antenna with at most 12 segments, together only half length of third segment (Fig. 19); maxillary palpus with an apical, irregular filament (Fig. 13) ..... **Pleroneura**
5. Clypeus with a large, median, acute tooth (Fig. 9); $Sc_2$ joined to R about one-third the distance between points of separation of M and Rs (Fig. 5), **Megaxyela**
   Clypeus with median lobe rounded, slightly indentate on meson (Fig. 10); $Sc_2$ joined to R at most one-quarter the distance between points of separation of M and Rs (Fig. 6) ..... **Macroxyela**

## Genus **Xyela** Dalman.

*Xyela* Dalman, Svensk. Vetensk. Acad. Handl., Vol. 40, 1819, No. 3, p. 122; Curtis, British Entomology, Pl. 30, July 1, 1824, Vol. III of revised edition; Ashmead, Psyche, Vol. 8, No. 265, May, 1898, p. 214; Can. Ent., Vol. XXX, No. 8, Aug., 1898, p. 206; Rohwer, Proc. U. S. Nat. Mus., Vol. 45, No. 1981, May 22, 1913, p. 265; MacGillivray, Bull. 22, Conn. Geol. Nat. Hist. Surv., 1916, p. 30; Enslin, Deut. Ent. Zeit., 1917, Beiheft 2, July, 1918, p. 679.
*Pinicola* Brebisson, Bull. Soc. Philom. Paris, 1818, p. 116.
*Tritokreion* Schilling, Ubers. Arbeit. Schles. Ges. Vaterl. Cultur., 1825, p. 43.
*Mastigocerus* Klug, 18—. Reference unknown, a synonym of *Xyela* by Lepeletier (Rohwer, 1911).

*Tritokreion* Schilling is quoted by Rohwer (1911) as being without a species, but is definitely placed as a synonym of *Xyela* by Enslin (1918).

*Characteristics.*—Antennal thread 9-segmented, as long as, or longer than, third antennal segment. Maxillae as in Figure 13; lacinia lobe-like; galea with an apical portion demarked by a crease, thus forming a distal "segment" which is tentatively called the distagalea; palpus with third segment very long, terminal thread mostly membranous, indistinctly divided into several segments. Front wings (Fig. 2) with subcosta typically united with radio-medial stem, so that subcosta 2 is repressed, subcosta 1 distinct; medio-cubital cross-vein variable in position, and other cross-veins liable to atrophy haphazardly; hind wings with only one closed submarginal cell. Tarsal claws with a small tooth. Female with sheath either straight or curving ventrad, very similar in shape to that of *Neoxyela alberta* Curran (Fig. 18).

*Genotype.*—*Xyela pusilla* Dalman, by subsequent designation of Curtis (1824).

The nearctic species of this genus were synopsized by Rohwer (*loc. cit.*, 1913). Since that date only one Nearctic species has been described in the genus, viz., *Xyela intrabilis* MacGillivray (Bull. Brooklyn Ent. Soc., Vol. XVIII, No. 2, May, 1923, p. 53), which is very closely allied to, or synonymous with, *Xyela bakeri* Konow.

The larva of one species, *X. minor* Norton, has been described and recorded as feeding on the staminate cones of pine by Dyar (1898).

## Genus **Neoxyela** Curran.

*Neoxyela* Curran, Can. Ent., Vol. LV, No. 1, Jan., 1923, p. 20.

*Genotype.*—*Neoxyela alberta* Curran, by original designation, and monobasic.

The species for which Curran erected this genus displays several aberrations of wing venation. Both wings, as indicated in the original description, have lost vein radius 2, but in one wing of the paratype the stub of the vein occurs (Fig. 4), indicating the primitive possession of it. Should this represent the true position of the base of radius 2, it differs from other members of *Xyela* in being midway between the bases of radius 4 and radius 5, in other members of the family being close to or basad of radius 5. The two wings of the paratype differ markedly in regard to the subcostal vein: one has it fused with radio-medial stem as in *Xyela*, but with subcosta 1 atrophied; the other (Fig. 4) has it distinct and separate from radio-medial stem, and with both branches present, closely approaching the condition found in *Pleroneura*. In other

respects—mouthparts, antennae and genitalia—*Neoxyela alberta* is a typical *Xyela*.

**Neoxyela alberta** Curran.

*Neoxyela alberta* Curran, Can. Ent., Vol. LV, No. 1, Jan., 1923, p. 20, ♀.

*Holotype.*—No. 520, Canadian National Museum; ♀, Banff, Alberta, May 27, 1922 (C. B. D. Garrett).

This species, which was described from two specimens, is the only one known in the genus.

Genus **Pleroneura** Konow.

*Pleroneura* Konow, Ent. Nachr., Vol. 23, 1897, p. 56; Rohwer, Bull. U. S. Dept. Agric.. Bur. Ent., Tech. Ser., No. 20, Pt. II, March 4, 1911, p. 87; Enslin, Deut. Ent. Zeit. f. 1917, Beiheft 2, July, 1918, p. 679.

*Pleuroneura* Ashmead, Psyche, Vol. 8, No. 265, May, 1898, p. 214; Can. Ent., Vol. XXX, No. 8, Aug., 1898, p. 206; MacGillivray, Bull. 22, Conn. Geol. Nat. Hist. Surv., 1916, p. 30.

*Manoxyela* Ashmead, Psyche, Vol. 8, No. 265, May, 1898, p. 214; Can. Ent., Vol. XXX, No. 8, Aug., 1898, p. 206; Rohwer, Bull. U. S. Dept. Agric., Bur. Ent., Tech. Ser., No. 20, Pt. II, p. 104.

*Characteristics.*—Antennae (Fig. 19) with terminal filament much shorter than third segment, composed of 8 segments. Maxillae as in *Xyela* (Fig. 13). Front wings (Fig. 3) with subcosta short, joining radio-medial stem before separation of radius and media, and separate from it, with both branches distinct; medio-cubital cross-vein interstitial with or distad of radius 5. Hind wings (Fig. 7) with only one closed submarginal cell. Female with the sheath curving dorsad (Fig. 23).

*Genotype.*—*Xyela dahli* Hartig, by subsequent designation of Rohwer (1911).

The genus *Manoxyela* Ashmead was originally described as a genus closely related to *Xyela*, having the long terminal antennal filament and subcosta fused with radio-media. Rohwer (1911) states that the genotype, *M. californica* Ashmead, belongs to the genus *Pleroneura*, thus reducing *Manoxyela* to synonymy.

Judging by similarity of mouth parts and certain characters of the wings, especially the shortness of subcosta, the position of medio-cubital cross-vein and the one closed submarginal cell in the hind wings, this genus is very closely related to *Xyela*. It is readily separated, however, on the basis of the short antennal thread and the separate course of subcosta.

Most of the Nearctic species placed in this genus have been described from a very few specimens. It is therefore impossible, until large series are examined, to know how stable are the characters upon which the present species are separated.

KEY TO THE NEARCTIC SPECIES OF PLERONEURA.

1. Head and thorax mostly black ..... 3
   Head and thorax not mostly black ..... 2
2. Postocellar line present; thorax and abdomen not marked with black; length, 4.5 mm.; anterior lobes of mesonotum punctured similarly to side lobes ..... **lutea**
   Postocellar line absent; thorax and abdomen marked with black; length, 6 mm.; anterior lobe of mesonotum more closely sculptured than side lobes ..... **koebelei**
3. Femora pale ..... 4
   Femora black ..... 6
4. Posterior margin of collar black ..... **californica**
   Posterior margin of collar pale ..... 5
5. First recurrent nervure (*r-m*) and first transverse cubital (*m-cu*) interstitial, **brunneicornis**
   First recurrent nervure (*r-m*) and first transverse cubital (*m-cu*) not interstitial ..... **borealis**
6. Middle and hind tibiae black; clypeus black ..... **schwarzi**
   Middle and hind tibiae mostly dark rufous; clypeus with anterior half yellow ..... **aldrichi**

### **Pleroneura brunneicornis** Rohwer.

*Pleroneura bruneicornis* Rohwer, Can. Ent., Vol. 42, No. 3, Mar., 1910, p. 89, ♀.
*Pleroneura brunneicornis* Rohwer, *ibid*, No. 6, June, 1910, p. 220; MacGillivray, Bull. 22, Conn. Geol. Nat. Hist. Surv., 1916, p. 30.

*Type.*—No. 12750 in the U. S. National Museum. Described from a single female, Gloversville, N. Y., April 30, 1907 (C. P. Alexander).

### **Pleroneura californica** (Ashmead).*

*Manoxyela californica* Ashmead, Psyche, Vol. 8, No. 265, May, 1898, p. 214; Dyar, Can. Ent., Vol. 30, No. 7, July, 1898, p. 174.
*Pleroneura fulvicornis* Rohwer, Can. Ent., Vol. 42, No. 3, March, 1910, p. 89, ♂.
*Pleroneura californica* Rohwer, Bull. U. S. Dept. Agric., Bur. Ent., Tech. Ser., No. 20, Pt. II, March 4, 1911, p. 104, ♀?.

Ashmead published the name *Manoxyela californica* as the type of the new genus *Manoxyela*. This generic placing was misleading in the extreme, but Rohwer, in 1911, described Ashmead's type specimen, and gave its correct generic position.

*P. fulvicornis* is probably the male of *P. californica* for both species were described from the same region and their descriptions are almost identical except for slight characters which could easily be antigenetic. Mr. Rohwer has expressed, in correspondence, a similar belief in the possibility of the two being conspecific.

*Type.*—No. 8887, U. S. National Museum; ♀?, Alameda County, California, June.

*I am greatly indebted to Mr. S. A. Rohwer for much valuable correspondence in regard to the status, synonymy and characteristics of this species.

Type of *fulvicornis*, No. 12749 in the U. S. National Museum, described from one male, Placer County, California, June. Two males have been examined from Vancouver, B. C., collected May 12, 1931, by H. B. Leech.

**Pleroneura schwarzi** Rohwer.

*Pleroneura schwarzi* Rohwer, Can. Ent., Vol. XLII, No. 6, June, 1910, p. 220, ♀.

*Type.*—No. 13081, in the U. S. National Museum. Described from one female, Alta, Utah, June 30 (E. A. Schwarz).

**Pleroneura borealis** Felt.

*Pleroneura borealis* Felt, Can. Ent., Vol. XLIX, No. 6, June, 1917, p. 191, ♂, ♀.

Lectotype ♀ and lectoallotype ♂ in the collection of the New York State Museum, Albany, N. Y., both from Lake Clear, N. Y., June 7, 1906.

**Pleroneura aldrichi** new species.

*Female.*—Length of body, exclusive of antennae and sheath, 5.5 mm.; length of front wing, 6.5 mm., and length of sheath, 2.25 mm. Head, including antennae, black, with the mandibular basal membrane, labrum, and about the apical third of the clypeus, yellow, and with the apical portion of the mouthparts brownish yellow; thorax black; abdomen brownish black, the apical segments shading to reddish brown, every segment with the apical margin narrowly bordered with yellowish white; legs with coxae, trochanters and femora black, the front and middle trochanters with a small yellowish line at apex, all the tibiae and tarsi dull brown, slightly lighter at base, the hind tibiae and tarsi somewhat dusky towards the apex; wings uniformly brown infuscate, stigma and veins bright brown.

Anterior margin of clypeus produced on meson into a short, obtuse lobe. Entire dorsum of head finely granular, dull; ocellar basin flat, bounded by the antennal furrows, which are distinct and line-like, meeting behind the median ocellus; a small, rounded depression just anterior to median ocellus; vertical furrows barely indicated. Mesonotum dull, somewhat shagreened; tibiae hairy, with stout spines; tarsal claws slender, simple, without a tooth. Abdomen finely punctate but shining; sheath as in Figure 23, curving upwards, sabre-like, the apex pointed.

*Male.*—Length of body, excluding antennae, 5.5 mm., length of wings as in female. Color almost identical with female, differing in having the tibiae and tarsi slightly darker, and the apex of the abdomen, including the claspers, black or very dark brownish black. Structure as in female.

*Holotype.*— ♀, Moscow, Idaho (J. M. Aldrich). Deposited in the collection of the Illinois State Natural History Survey, Urbana, Ill.

*Allotype.*—♂, same data, and deposited with holotype.

*Paratypes.*—1 ♀, same data, and 1 ♂, Moscow Mt., Idaho, May 25, 1905 (J. M. Aldrich). Deposited in the collections of the University of Idaho and with the holotype.

This species is apparently very closely allied to, if not the same as, *P. schwarzi* Rohwer. It differs from the description of the latter, however, in having the labrum and anterior third of the clypeus yellow, in having most of the tibiae and tarsi reddish, and in its slightly larger size.

**Pleroneura koebelei** Rohwer.

*Pleroneura koebelei* Rohwer, Can. Ent., Vol. XLII, No. 3, March, 1910, p. 90, ♂.

*Type.*—No. 12752, in the U. S. National Museum. Described from one male, Oregon (Koebele).

**Pleroneura lutea** Rohwer.

*Pleroneura lutea* Rohwer, Can. Ent., Vol. XLII, No. 3, March, 1910, p. 90, ♂.

*Type.*—No. 12751, in the U. S. National Museum. Described from Oregon (Koebele).

Genus **Xyelecia** new genus.

*Characteristics.*—Antennae very long (Fig. 20), antennal thread longer than third segment, *composed of 24 or more segments.* Maxillae as in Figure 12; lacinia knob-like; distagalea distinct and lobe-like, with short, peg-like setae; palpus with third segment very long, terminal thread fused into a simple, elongate, semi-membranous segment, clothed with long setae. Front wings (Fig. 1) with subcosta distinct and short, subcosta 2 joining radio-media before separation of radius and media; medio-cubital cross-vein joining media and cubitus close to origin of media much basad of radio-medial cross-vein. Hind wings (Fig. 7) with only one closed submarginal cell. Tarsal claws with a minute tooth near apex. Female with sheath short and broad (Fig. 16), quite unlike any other known members of the family.

*Genotype.*—*Xyelecia nearctica* new species.

This genus possesses a combination of the characteristics of the *Xyela* group and the group to follow containing *Macroxyela*. It is distinguished from all other members of the family by the long antennal thread and the short, broad sheath. From *Xyela* and *Pleroneura* it can be distinguished by the proximal position of medio-cubital cross-vein in the front wing; and from *Macroxyela* and *Megaxyela* by having only one closed submarginal cell in the hind wings, and by the short subcosta in the front wings.

**Xyelecia nearctica** new species.

*Female.*—Length from head to apex of sheath, 8 mm.; length of front wing, 9 mm. Antennae and eyes entirely black, remainder of head mottled with clayish white, brownish rufous and blackish brown; the blackish brown distributed over the following parts: entire caudal aspect of head, all sutures and furrows of other aspects, narrow lunule on posterior margin of eye, more or less of central portion of postocellar area, area around ocelli, and a linear area extending from the base of the antennae to the posterior margin of the head, the caudal halves forming areas which are laterally circularly convex, separated from the eyes by a whitish line; eyes (including the posterior black lunule) surrounded by a narrow, creamy white area, sometimes stained with brownish; supraclypeal area and ocellar basin reddish brown, the latter with a black line from the anterior ocellus to the median fovea; mouth-parts with chitinized portions black and membranous portions luteous, except mandibles, which have the apices reddish; labrum yellowish white with apical margin stained with brown and latero-basal portions black; clypeus yellowish with a small central brownish spot.

Thorax mostly blackish brown, with the following parts rufous: pronotum (except some portions of the margins), the anterior lobe entirely, the lateral lobes (except an antero-lateral spot and the depressed postero-lateral areas, which are black), the anterior angle of the scutum and a line along the oblique dorsal suture of the meso-episternum. Coxae with base black, apices usually reddish brown; trochanters, all the femora and the front and middle tibiae, reddish brown; front and middle tarsi with basitarsus yellowish or reddish, remaining segments brownish black; hind tibiae and tarsi black. Wings hyaline, iridescent, slightly stained with brown along veins at apex; stigma and veins brown.

Abdomen black with the apical one or two terga and sterna rufous, as are also most of the basal portion of the sheath and the sclerites forming its base.

Habitus and most of the proportions as in other Xyelids. Head finely punctured, minutely shagreened, uniformly shining, but not polished; labrum almost as wide as clypeus, almost truncate; clypeus as in Figure 8, symmetrical as in *Xyela*, with the anterior margin produced on the meson to form a tooth, and with a longitudinal mesal carina, which is rounded and more or less bulbous in the centre; supraclypeal area gently convex; ocellar basin very slightly excavated and trough-like, divided on the meson by a fine furrow running from the median ocellus to the median fovea; median fovea a small, ellipsoid, shining pit on a line between the dorsal margins of the antennal foramina; antennal furrows meeting behind median ocellus, distinct for two-thirds of distance to antennae, then becoming vague; vertical furrows line-like, thin but distinct from ocelli to occiput. Third antennal segment slightly longer than greatest width of head, and approximately the width of the front tibiae; terminal filament long, very thin, each segment from three to four times as long as wide (Fig. 20).

Dorsum of thorax somewhat shining, slightly more so than head. Dorsum of abdomen very finely shagreened, glossy when seen from some angles. Sheath as in Figure 16, large and broad but thin, with a longitudinal, wide, low ridge extending to the apex; dorsal portion and ridge polished, ventral portion minutely shagreened; cerci very small, with some long spines at apex; a group of four or five spines originating dorsad of the cerci extending caudad almost as far as tip of sheath. Legs slender, front tibiae without preapical spines, middle tibiae with three and hind tibiae with four. Venation of front wing as in Figure 1; hind wing with venation differing from Figure 7 only in having subcosta either almost coalesced with radio-medial stem or absent, and with the lower closed cell slightly longer.

*Male*—Unknown.

*Holotype.*— ♀, White Branch Meadow, Three Sisters, Frog Camp, Oregon, elevation approximately 5,500 ft., July 19, 1927 (H. A. Scullen). Deposited in the collection of the Illinois State Natural History Survey.

*Paratype.*— ♀, Moscow, Idaho (J. M. Aldrich). Deposited in the Canadian National Museum.

This species is the only one yet known in the genus. It is very distinctly characterized by the extremely aberrant type of sheath, the long antennal thread and the wing venation.

## Genus **Megaxyela** Ashmead.

*Megaxyela* Ashmead, Psyche, Vol. 8, No. 265, May, 1898, p. 214; Dyar, Can. Ent., Vol. XXX, No. 7, July, 1898, p. 174, 175; Ashmead, *ibid.*, No. 8, Aug., 1898, p. 206; Konow, Genera Insectorum, 27me. Fasc., 1905, p. 22; Rohwer, Bull. U. S. Dept. Agric., Bur. Ent., Tech. Ser., No. 20, Pt. II, March 4, 1911, p. 83; MacGillivray, Bull. 22, Conn. Geol. Nat. Hist. Surv., 1916, p. 31.

*Pleuroneura* Ashmead, Psyche, Vol. 8, No. 265, May, 1898, p. 214; Dyar, Can. Ent., Vol. XXX, No. 7, July, 1898, p. 174; Ashmead, *ibid.*, No. 8, Aug., 1898, p. 206.

*Odontophyes* Konow, Wien. Ent. Zeit., Vol. 18, 1899, p. 42 (type, *Pleuroneura aviingrata* Dyar); Genera Insectorum, 27me, Fasc., 1905, p. 22; Rohwer, Bull. U. S. Dept. Agric., Bur. Ent., Tech. Ser., No. 20, Pt. II, March 4, 1911, p. 85; MacGillivray, Bull. 22, Conn. Geol. Nat. Hist. Surv., 1916, p. 30. *New synonymy.*

*Paraxyela* MacGillivray, Can. Ent., Vol. XLIV, No. 10, Oct., 1912, p. 294 (type, *Xyela tricolor* Cresson); Bull. 22, Conn. Geol. Nat. Hist. Surv., 1916, p. 31. *New synonymy.*

*Characteristics.*—Clypeus with a large, median, triangular tooth (Fig. 9). Antennae with third segment very large, the terminal filament short, eight or nine segmented, in relation to the third segment only about half as long as in *Pleroneura* (Fig. 19). Maxillae as in Figure 15; lacinia spatulate; mesal lobe of galea (distagalea) short and broad; palpi four segmented, the last two subequal, the fourth chitinized, with only weak setae, the apex membranous. Labial palpus four segmented (Fig. 14). Front wings with subcosta (Fig. 5) distinct and long, subcosta 2 joining radius at from one-quarter to one-third the distance

between points of separation of media and radial sector. Hind wings (Fig. 11) with two closed submarginal cells. Tarsal claws deeply cleft, the two rays strong and subparallel.

*Genotype.*—*Xyela major* Cresson (original designation).

KEY TO THE NEARCTIC SPECIES OF MEGAXYELA.

1. Males (apical sternum flat, not divided on meson)..... 2
   Females (apex of abdomen with a sheath-like structure)..... 4
2. Entire body yellowish brown.....**major**
   Dorsum of head and thorax bronze, of abdomen blue..... 3
3. Mesopleurae and pectus blue.....**tricolor**
   Mesopleurae and pectus rufous.....**bicoloripes**
4. Entire body yellowish brown.....**major**
   Dorsum black or bronze..... 5
5. Mesopleurae and pectus blue.....**aviingrata**
   Mesopleurae and pectus rufous.....**bicoloripes**

### **Megaxyela major** (Cresson).

*Xyela major* Cresson, Trans. Amer. Ent. Soc., Vol. VIII, Jan., 1880, p. 34, ♀, ♂; Mem. Amer. Ent. Soc., No. 1, 1916, p. 5.
*Macroxyela major* Kirby, List Hymen. Brit. Mus., Vol. 1, 1882, p. 351.
*Megaxyela major* Ashmead, Psyche, Vol. 8, No. 265, May, 1898, p. 214; Dyar, Can. Ent., Vol. XXX, No. 7, July, 1898, p. 174, 175; Ashmead, *ibid.*, No. 8, Aug., 1898, p. 206; MacGillivray, Bull. 22, Conn. Geol. Nat. Hist. Surv., 1916, p. 31; Yuasa, Ill. Biol. Monographs, Vol. VII, No. 4, Oct., 1922, p. 41.
*Odontophyes ferruginea* Bridwell, Ent. News, Vol. 17, No. 3, March, 1906, p. 94, ♀. *New synonymy.*

This large species has been described from Texas (Cresson) and from Baldwin, Kansas, in April, upon the flowers of the early shrub willow (Bridwell). An additional male specimen has been studied from McLean, N. Y., April 26, 1913 (H. H. Knight). Yuasa and Dyar have described the larvae from hickory and pecan.

*Type.*—No. 330 in the collection of the Academy of Natural Sciences of Philadelphia.

### **Megaxyela tricolor** (Norton).

*Xyela tricolor* Norton, Proc. Ent. Soc. Philadelphia, Vol. I, Feb., 1862, p. 144, ♂; Trans. Amer. Ent. Soc., Vol. II, 1869, p. 348; Cresson, Mem. Amer. Ent. Soc., No. 5, 1928, p. 9, 85.
*Macroxyela tricolor* Kirby, List Hymen. Brit. Mus., Vol. I, 1882, p. 352; Dyar, Can. Ent., Vol. XXX, No. 7, July, 1898, p. 174; Konow, Genera Insectorum, 27 me. Fasc., 1905, p. 22.
*Paraxyela tricolor* MacGillivray, Can. Ent., Vol. XLIV, No. 10, Oct., 1912, p. 294; Bull. 22, Conn. Geol. Nat. Hist. Surv., 1916, p. 31.

Described from Kansas. Male specimens have been examined from Algonquin, Illinois, and Urbana, Illinois, April 12, 1891 (C. A. Hart).

*Type.*—No. 331 in the collection of the Academy of Natural Sciences of Philadelphia.

In discussing the question of the two sexes of this species, it is perhaps indicative to note that *M. tricolor*, known only from the male, differs from the male of *M. bicoloripes* chiefly in the black pleurae, pectus and venter, and that *M. aviingrata*, known only from the female, differs from the female *bicoloripes* chiefly in these same characters. In generic characters, *tricolor* and *aviingrata* are identical. They have been placed in separate genera on the basis of the teeth of the tarsal claws, but this character is so essentially one of small shade of degree that it is doubtful if it is even specific. The two differ chiefly (excluding genitalic characters, since they are known only from opposite sexes) in the color of the legs, *tricolor* having them rufous with the hind tibiae and hind tarsi black, *aviingrata* having them entirely black except the four apical segments of the hind tarsi, which are white. It is not impossible that these differences are only antigenetic, and the two species may ultimately be shown to be the two sexes of the same species.

**Megaxyela aviingrata** (Dyar).

*Pleuroneura aviingrata* Dyar, Psyche, Vol. 8, No. 265, May, 1898, p. 213, ♀; Can. Ent., Vol. XXX, No. 7, July, 1898, p. 174, 176.

*Odontophyes aviingrata* Konow, Wien. Ent. Zeit., Vol. 18, 1899, p. 42; Genera Insectorum, 27me. Fasc., 1905, p. 22; MacGillivray, Bull. 22, Conn. Geol. Nat. Hist. Surv., 1916, p. 30; Yuasa, Ill. Biol. Monographs, Vol. VII, No. 4, Oct., 1922, p. 41.

*Odontophyes avingrata* Rohwer, Mem. 101, Cornell Univ. Agric. Exp. Stat., Jan., 1928, p. 871.

Both the adult female and the larval stages were originally described by Dyar from the following localities: Staten Island, N. Y., June 1; Bellport, Long Island; Bedford Park, N. Y., May 25; Fort Lee and Plainfield, N. Y., May 16. The "New York List" records an additional locality, Ithaca, April 29 (Knight). The following specimen has been examined by the author: ♀, Pine, Indiana, May 21, 1905 (W. J. Gerhard). The larvae feed on hickory and butternut. Two larvae have been collected by the author on hickory at Charleston, Illinois, May 31, 1931.

Type in the U. S. National Museum.

**Megaxyela bicoloripes** (Rohwer).

*Odontophyes bicoloripes* Rohwer, Proc. Ent. Soc. Wash., Vol. 26, No. 8, Nov., 1924, p. 215, ♀.

Originally described from a single female, Agricultural

College, Mississippi, April 6, 1915 (A. E. Barbin). Holotype, No. 26040 in the U. S. National Museum.

*Male.*—What is considered as the male of this species agrees very well with the description of the female, differing in having all the sterna rufous, the apical ones clouded with blackish, and the mesal margins of the ventral portions of the terga white. The hind tarsi are lacking, but due to its similarity to *tricolor* in other respects, it is supposed that they are alike in this also, and that they are black. The single specimen at hand is structurally identical, or almost so, with *tricolor*, differing in color in having the mesopleurae, pectus and abdominal sterna rufous.

*Allotype.*—♂, "Penn." (=Pennsylvania). In the collection of the Illinois State Natural History Survey.

## Genus **Macroxyela** Kirby.

*Macroxyela* Kirby, List Hymen. Brit. Mus., Vol. I, 1882, p. 351; Ashmead, Psyche, Vol. 8, No. 265, May, 1898, p. 214; Can. Ent., Vol. XXX, No. 8, Aug., 1898, p. 206; Rohwer, Bull. U. S. Dept. Agric., Bur. Ent., Tech. Ser., No. 20, Pt. II, March 4, 1911, p. 83; MacGillivray, Bull. 22, Conn. Geol. Nat. Hist. Surv., 1916, p. 31.

*Protoxyela* MacGillivray, Can. Ent., Vol. XLIV, No. 10, Oct., 1912, p. 294 (type, *Xyela aenea* Norton); Bull. 22, Conn. Geol. Nat. Hist. Surv., 1916, p. 31.

*Characteristics.*—Clypeus (Fig. 10) with a median lobe which is immarginate, forming two small, rounded lobes, one on each side of the meson. Antennae, maxillae, hind wings and tarsal claws as in *Megaxyela*. Labial palpus three segmented. Front wings differing from those of *Megaxyela* only in having subcosta slightly shorter (Fig. 6), joining radius less than a quarter of the distance between points of separation of media and radial sector.

*Genotype.*—*Xyela ferruginea* Say (original designation).

KEY TO THE NEARCTIC SPECIES OF MACROXYELA.

1. Males (apical sternite flat, not divided on meson) ..... 2
   Females (apex of abdomen with a sheath-like structure) ..... 5
2. Head and thorax bronze, abdomen yellowish rufous ..... 3
   Head, thorax and abdomen bronze or blue ..... 4
3. Wings almost hyaline, irregularly stained with tawny ..... **bicolor**
   Wings deep brown infuscate, violaceous at base ..... **bicolor** var. **harti**
4. Radial region of front wing with one or more accessory cross-veins (Fig. 6), **aenea**
   Radial region of front wing without accessory cross-veins (cf. Fig. 1), **ferruginea**
5. Dorsum mostly ferruginous, with various blackish markings; sheath more slender (Fig. 22) ..... **ferruginea**
   Dorsum almost entirely bluish or bronze; sheath shorter and stouter (Fig. 21) ..... **aenea**

**Macroxyela aenea** (Norton).

*Xyela aenea* Norton, Trans. Amer. Ent. Soc., Vol. IV, May, 1872, p. 86, ♂; Cresson, *ibid.*, Vol. VIII, 180, p. 48; Mem. Amer. Ent. Soc., No. 5, 1928, p. 3, 85.
*Macroxyela aenea* Kirby, List. Hymen. Brit. Mus., Vol. I, 1882, p. 352; Dyar, Can. Ent., Vol. XXX, No. 7, July, 1898, p. 174; Konow, Genera Insectorum, 27me. Fasc., 1905, p. 22.
*Protoxyela aenea* MacGillivray, Can. Ent., Vol. XLIV, No. 10, Oct., 1912, p. 294; Bull. 22, Conn. Geol. Nat. Hist. Surv., 1916, p. 31.

This species differs markedly from *M. ferruginea* in having both sexes concolorous. The females are easily separated on the basis of color, but the males are very similar. All those examined, however, can be separated on the basis of the accessory radial cross-veins (Fig. 6).

*Type.*—No. 332 in the collection of the Academy of Natural Sciences of Philadelphia. Described from Texas and recorded from Staten Island, N. Y. I have not examined the specimens upon which the New York record is based.

**Macroxyela ferruginea** (Say).

*Xyela ferruginea* Say, Long's 2nd. Exp., ii, 1824, App., p. 310, ♀; Norton, Trans. Amer. Ent. Soc., Vol. II, 1869, p. 348.
*Macroxyela ferruginea* Kirby, List Hymen. Brit. Mus., Vol. I, 1882, p. 351; Dyar, Can. Ent., Vol. XXX, No. 7, July, 1898, p. 174; Konow, Genera Insectorum, 27me. Fasc., 1905, p. 22; MacGillivray, Bull. 22, Conn. Geol. Nat. Hist. Surv., 1916, p. 32; Yuasa, Ill. Biol. Monographs, Vol. VII, No. 4, Oct., 1922, p. 42; Garlick, Can. Ent., Vol. LV, No. 11, Nov., 1923, p. 256.
*Xyela infuscata* Norton, Proc. Boston Soc. Nat. Hist., Vol. VIII, 1861, p. 224, ♂; Trans. Amer. Ent. Soc., Vol. II, 1869, p. 349. *New synonymy.*
*Macroxyela infuscata* Kirby, List Hymen. Brit. Mus., Vol. I, 1882, p. 351; Dyar, Can. Ent., Vol. XXX, No. 7, July, 1898, p. 174; MacGillivray, Bull. 22, Conn. Geol. Nat. Hist. Surv., 1916, p. 32.
*Macroxyela obsoleta* MacGillivray, Can. Ent., Vol. XLIV, No. 10, Oct., 1912, p. 294, ♀; Bull. 22, Conn. Geol. Nat. Hist. Surv., 1916, p. 32; Frison, Bull. Ill. Nat. Hist. Surv., Vol. XVI, Art. IV, Feb., 1927, p. 243. *New synonymy.*
*Macroxyela distincta* MacGillivray, Can. Ent., Vol. XLIV, No. 10, Oct., 1912, p. 295, ♀; Bull. 22, Conn. Geol. Nat. Hist. Surv., 1916, p. 32; Frison, Bull. Ill. Nat. Hist. Surv., Vol. XVI, Art. IV, Feb., 1927, p. 234. *New synonymy.*
*Typic locality.*—Arkansas.

That *M. infuscata* was the male of *M. ferruginea* has been surmised for some time by taxonomists and was definitely expressed in correspondence between Dr. T. H. Frison and Mr. S. A. Rohwer in 1927. Yuasa keyed the larva of this species and recorded the host as elm. Garlick (*loc. cit.*) has recorded some interesting feeding habits of the adults, which ate out the buds of elm, pear and plum.

The following records of this species have been examined: IDAHO—1 ♂, Moscow. ILLINOIS—Many ♂ ♂ and ♀ ♀, Carmi, Havana, Homer, Normal, St. Joseph, Sterling, Urbana and

White Heath, March to June. IOWA—3 ♀ ♀, Ames, April 16, 1897; 2 ♀ ♀, Mt. Pleasant, April 6, 1927 (Davison). KANSAS—1 ♂, Manhattan, May, 1923. MAINE—2 ♀ ♀, Columbia, April 16, 1904. MASSACHUSETTS—2 ♂ ♂, Northampton, March 29, 1898. MISSOURI—1 ♂, 1 ♀, Kansas City. NEW YORK—2 ♀ ♀, Albany, April 27, 1902; 4 ♂ ♂, 1 ♀, Ithaca, April, 1913.

**Macroxyela bicolor** MacGillivray.

*Macroxyela bicolor* MacGillivray, Can. Ent., Vol. XLIV, No. 10, Oct., 1912, p. 294, ♂; Frison, Bull. Ill. Nat. Hist. Surv., Vol. XVI, Art. IV, Feb., 1927, p. 234.

*Type.*—♂, Columbus, Ohio (J. S. Hine), in the MacGillivray Collection, University of Illinois.

This species was originally described from two males from Columbus, Ohio, and has not since been recorded. It is very similar in structure to *M. ferruginea*, differing only in color, having the abdomen yellow instead of bronze or bluish. The female is not known.

**Macroxyela bicolor** var. **harti** new variety.

*Male.*—Similar in size, structure and color of body to the typical form of *bicolor*, differing in having the wings infuscate with deep brown, strongly violaceous at the base.

*Holotype.*—♂, Havana, Illinois, April, 1896 (C. A. Hart) (Acc. No. 20284). Deposited in the collection of the Illinois State Natural History Survey, Urbana, Ill.

Known only from the holotype.

**Macroxyela angulata** MacGillivray.

*Macroxyela angulata* MacGillivray, entry in Mem. 101, Cornell Univ. Agric. Exp. Stat., Jan., 1928, p. 871.

Professor J. Chester Bradley has kindly informed me in correspondence that this entry in the "New York List of Insects" is a clerical error, referring to *Itycorsia angulata* MacGillivray listed in the same volume on page 872. MacGillivray did not describe a species *angulata* in the genus *Macroxyela*.

## EXPLANATION OF PLATES.

### Plate I.

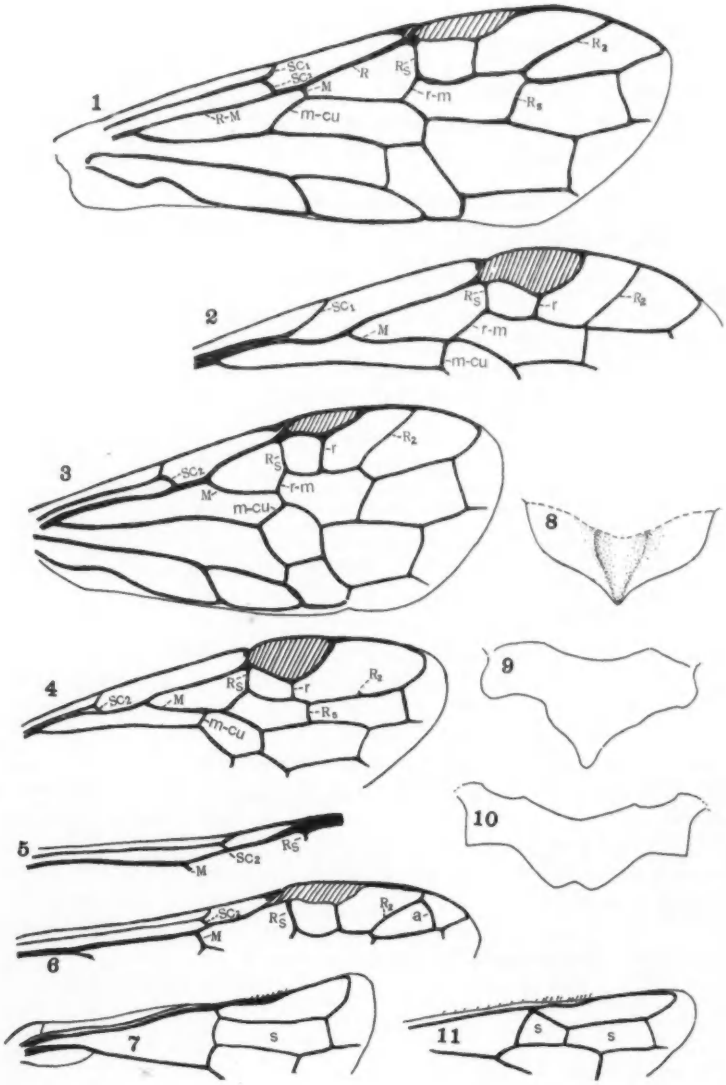
Fig. 1. Front wing of *Xyelecia nearctica*.
Fig. 2. Portion of front wing of *Xyela californica*.
Fig. 3. Front wing of *Pleroneura aldrichi*.
Fig. 4. Portion of front wing of *Neoxyela alberta*.
Fig. 5. Portion of front wing of *Megaxyela bicoloripes*.
Fig. 6. Portion of front wing of *Macroxyela aenea*.
Fig. 7. Portion of hind wing of *Pleroneura aldrichi*.
Fig. 8. Clypeus of *Xyelecia nearctica*.
Fig. 9. Clypeus of *Megaxyela major*.
Fig. 10. Clypeus of *Macroxyela aenea*.
Fig. 11. Portion of hind wing of *Megaxyela tricolor*.

### Plate II.

Fig. 12. Maxilla of *Xyelecia nearctica*.
Fig. 13. Maxilla of *Pleroneura aldrichi*.
Fig. 14. Labial palpus of *Megaxyela aviingrata*.
Fig. 15. Maxilla of *Macroxyela ferruginea*.
Fig. 16. Sheath of *Xyelecia nearctica*.
Fig. 17. Sheath of *Megaxyela aviingrata*.
Fig. 18. Sheath of *Neoxyela alberta*.
Fig. 19. Antenna of *Pleroneura aldrichi*.
Fig. 20. Antenna of *Xyelecia nearctica*.
Fig. 21. Sheath of *Macroxyela aenea*.
Fig. 22. Sheath of *Macroxyela ferruginea*.
Fig. 23. Sheath of *Pleroneura aldrichi*.

## LIST OF ABBREVIATIONS.

a = accessory cross-vein.
c = cercus.
dg = distagalea.
g = galea.
l = lacinia.
M = media.
m-cu = medio-cubital cross-vein.
p = palpus.
R = radius.
r = radial cross-vein.
$R_2$ = vein radius 2 (= radius 2).
$R_5$ = vein radius 5.
Rs = radial sector.
R-M = radio-medial stem.
r-m = radio-medial cross-vein.
s = submarginal cell.
$Sc_1$ = subcosta 1.
$Sc_2$ = subcosta 2.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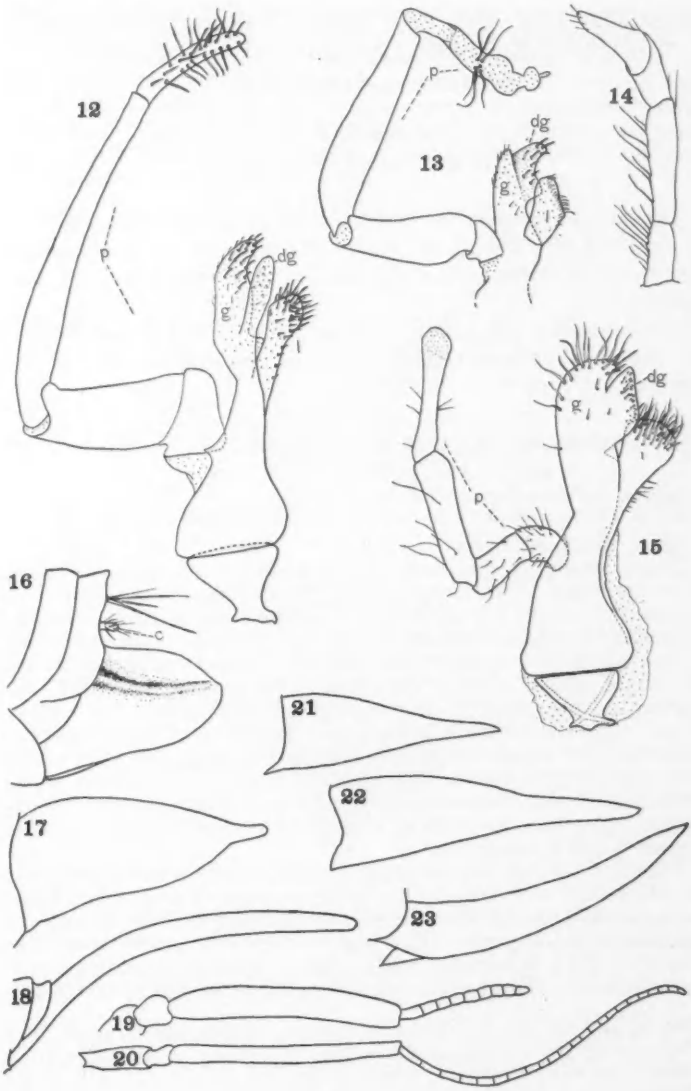
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# DESCRIPTION OF THE MALE OF STRUMIGENYS LOUISIANAE SUBSP. LATICEPHALA M. R. SMITH. (Hymen.: Formicidae).

GORDON W. HAUG,
A. & M. College, Mississippi.[1]

*Strumigenys louisianae* subsp. *laticephala* was described for the first time by Dr. M. R. Smith in his paper on *Strumigenys*.[2] The male of this ant, collected for the first time, is here described.

For notes on the distribution and habits of the members of the genus *Strumigenys*, the reader is referred to this recent paper of Dr. Smith.

**Strumigenys louisianae** subsp. **laticephala** M. R. Smith
(Text Figs. 1 and 2.)

*Strumigenys louisianae subsp. laticephala.*
M. R. SMITH. Ann. Ent. Soc. Amer., XXIV, (1931), 690–691, worker.

*Male.* Length 2.2 mm.

Head, excluding the mandibles, slightly longer than its width above the eyes. Eyes large, convex, sub-elliptical, and placed very close to the base of the mandibles. Ocelli conspicuous, almost colorless, and arranged in the form of a triangle with the distance between the two lateral ocelli greater than that between the median ocellus and one of the lateral ocelli. Mandibles small, poorly developed, and toothless. In shape they are elongate, tapering to very acute apical points. Clypeus strongly convex, in lateral profile protuberant. Antennal fossæ appearing as deep impressions along the sides of the head, extending from the base of the clypeus to almost the upper extremities of the compound eyes. Antennæ long, filiform, and of thirteen segments. Scape short, slightly longer than the first funicular segment which is subglobular.

Thorax robust, notauli (Mayrian furrows) on the anterior portion of the mesonotum very distinct, appearing as deep, rough grooves, which become shallow towards the median line and almost indistinguishable the remainder of the distance. They appear, therefore, as the unconnected arms of a "V." Mesonotum with a deep impression extending almost the entire length of the median line and with distinct parapsidal furrows.

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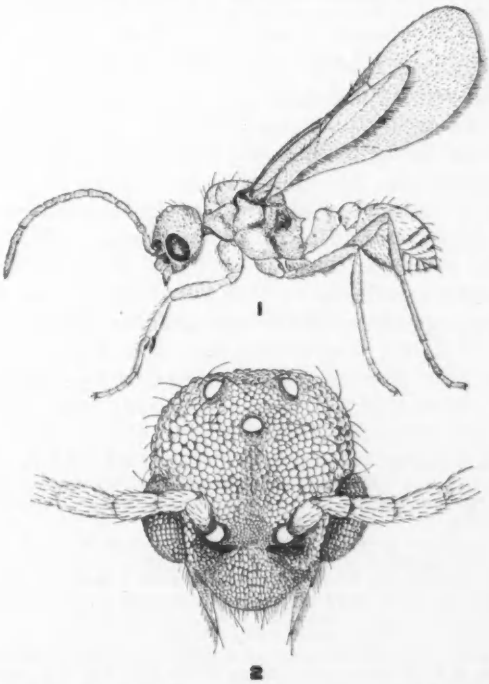
[1]A contribution from the Mississippi Agricultural Experiment Station.

[2]Smith, M. R., "A revision of the genus *Strumigenys* of America north of Mexico, based on a study of the workers," *Ann. Ent. Soc. Amer.*, XXIV, (1931), 686–710.

Wings with faint, pale brownish veins; iridescent. Anterior wings each with a closed costal and subcostal cell, and bearing many short, suberect hairs on the surfaces and around the anterior margins, and long ciliated hairs on the posterior margin around to the point where the discoidal and subdiscoidal vein approximates the posterior margin of the wing. Posterior wings lanceolate in shape, veinless, with many short suberect hairs on their surfaces and anterior borders, and long ciliated hairs on their posterior borders.



Male of *Strumigenys louisianæ* subsp. *laticephala* M. R. Smith.
Fig. 1. Lateral view of body. Fig. 2. Anterior view of head.
(All greatly enlarged. Illustrations by Mrs. S. H. DeBord.)

Legs long and slender. Epinotum sharply declinate, the basal surface and declivity subequal, and with the spiracle occurring on the posterior declivity of a prominent conical lateral elevation. Epinotal spines as broad as long, blunt, and directed backward and outward. Petiole, when viewed in lateral profile, with a low, moderately rounded node. Posterior border of superior margin faintly impressed medianly.

Postpetiole, viewed from above, transversely elliptical, one and one-half times the width of the petiole, with a transverse, acute ridge on its ventral surface.

Ground color of the body black, with an iridescent or metallic hue. Legs similar, with the tibiæ and tarsi paler. Mandibles and antennæ dusky brown.

Mandibles indistinctly but finely punctulate. Head and thorax, with the exception of the mesopleuræ, subopaque and coarsely punctate. Petiole, postpetiole, and gaster more finely so, with their dorsal surfaces smooth and shining.

Antennal hairs suberect, dense, and yellow. Those on the head, thorax and gaster rather sparse and darker in color.

Described from five alate males, which, with a dealated queen and 77 workers, were found by the writer, nesting under a discarded pot of earth in a Bermuda grass pasture at West Point, Mississippi, on June 20, 1930.

Cotypes are in the collections of the Department of Entomology of the Mississippi A. & M. College, Dr. M. R. Smith, and the writer.

Acknowledgment is due Dr. M. R. Smith, who has given many helpful suggestions in the preparation of this description.

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## BOOK NOTICE.

PLECOPTERA NYMPHS OF AMERICA (NORTH OF MEXICO), by PETER W. CLAASSEN, pp. 1-199, colored frontispiece and 238 figures on 35 plates; Thomas Say Foundation Vol. III, Charles C. Thomas, Publisher, Springfield, Illinois.

It seems superfluous to write a notice of a volume published by this Society, but we wish to call attention to this book on the nymphs of the Plecoptera which is a companion work to the Thomas Say Foundation Volume II, Plecoptera of North America. It is the only monographic treatise on the nymphs of the American species of this order of insects. The most prominent value of the volume lies in its numerous excellent illustrations. Professor Claassen is a good artist besides which help on the illustrations was available from the Heckscher Foundation. This type of work is very stimulating to the Editor as it brings on the old craving to cast every thing aside and to revert to the field and systematic entomology. Such an urge indicates that Professor Claassen has accomplished more than the mere writing of an excellent monograph. The table at the end of the volume shows that the nymphs of only sixty-eight of the two hundred and twelve described species are known. The volume makes possible intensive study of life histories, as every area of rapid streams north of Mexico contains undescribed material to be had for the collecting. Too few American entomologists realize the opportunities in the field of systematic entomology in North America. We are envied by every European entomologist. It has been bruited about that there exist American entomologists who look down upon systematic entomology, but pioneering work of the type done by Professor Claassen should make even these, if such really exist, begin to suspect that their point of view is open to serious question.—C. H. K.

# REVISION OF THE PLEUROSTICT SCARABAEIDAE OF CUBA AND THE ISLE OF PINES.

## I. THE MELOLONTHINAE.

EDWARD A. CHAPIN,
Taxonomic Investigations, Bureau of Entomology, United States Department of Agriculture.

The earliest writer to make known any member of the Cuban Melolonthinae was E. Blanchard, who, in 1850, published his Catalogue of the entomological collections of the Paris Museum. In it were described four Cuban species, one *Anoplosiagum* and three *Ancylonycha*. In 1855 Burmeister added three species of *Ancylonycha* to the list. The following year, Du Val, who wrote the Coleoptera portion of Sagra's History of Cuba, described as new four species of *Ancylonycha*, three of which are synonyms of Burmeister species. Nine years later, in 1865, Chevrolat gathered together the descriptions of the previously described species and added to the list one new *Anoplosiagum*, five new *Ancylonycha*, and a species of doubtful generic affinities. This work was hardly critical and it is often impossible to tell whether the author had or had not examined a species.

Since the appearance of Chevrolat's review (1865, Ann. Soc. Ent. France, Ser. 4, Vol. 5, pp. 21–28), no additions to the list have been made. In the many years which have elapsed since that date, a large amount of collecting has been done by various parties. As most of these collectors have been economic entomologists, it is to be expected that a large amount of material in this subfamily has accumulated. A working over of the available specimens has been necessary in order to permit greater accuracy in the discussion of white grub injury to sugar cane. Beside the collection of the National Museum, Messrs. S. C. Bruner and D. L. Van Dine transmitted to the writer the collections, respectively, of the Cuban Agricultural Experiment Station at Santiago de las Vegas and the Cuban Sugar Club Experiment Station at Baragua. This material was offered for study on the most generous terms, and for its use and for the

specimens retained for the National Collection the writer tenders his very great thanks. Acknowledgment is also due the Cuban Sugar Club for assuming a portion of the expense of publication of this report.

KEY TO THE CUBAN GENERA OF *Melolonthinae*.

1. Anterior tibia without calcar, tarsal claws simple or feebly toothed, *Anoplosiagum* (=*Clavipalpus* Chevr. 1865)
   Anterior tibia calcarate, tarsal claws strongly toothed, *Phyllophaga* (=*Ancylonycha*) (=*Lachnosterna*)

## **Anoplosiagum** Blanchard.

BLANCHARD, Cat. Col. Ent. Mus. Paris, 1: 119, 1850.[1]

Blanchard established this genus in 1850 for four species, three of which were from Brazil. The fourth, *A. pallidulum* Bl., is Cuban and is redescribed below. The genus represents the group Macrodactylides in the island fauna and the species belonging to it may be immediately recognized by the absence of the calcar of the anterior tibia. The Cuban species known to the writer may be separated in the following manner:

KEY TO THE GENUS *Anoplosiagum* Blanchard.

1. Head, pronotum, and elytra (except apices) black.....**variabile** Chevr.[2]
   Coloration not as above..... 2
2. Tarsal claws simple; color fuscous with lateral margins of pronotum irregularly, and a discal plaga on each elytron, pale (Page 175)..**simplicipes**
   Tarsal claws denticulate or split..... 3
3. Tarsal claws each with a minute, triangular denticle before the middle; elytra roughly and coarsely punctured; head dark with a pale median spot, disc of pronotum with a large pentagonal dark spot, elytra with margins and suture dark (Page 175).....**scabrosum**
   Tarsal claws split at or beyond middle..... 4
4. Form oval; tarsal claws stout, bent, the basal portion swollen; pygidium almost impunctate (Page 176).....**peltatum**
   Form narrowly oval or elongate; tarsal claws slender, somewhat curved, not broadened at base; pygidium distinctly punctured..... 5
5. Margin of pronotum finely denticulate; color uniform castaneous, (Page 177).....**rufum**
   Margin of pronotum entire; color usually not uniform, but if so, then nearly black..... 6
6. Color nearly uniform rufotestaceous (sides of pronotum pale); clypeus with a median smooth spot devoid of punctures (Page 177).....**pallidulum**
   Color either uniform piceous or yellowish-brown with two piceous spots on pronotum; clypeus coarsely and densely punctured (Page 178).....**rutilus**

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[1] *Anoplosiagum* was based on three Brasilian species and one Cuban. As the Cuban species was the last mentioned, I hesitate to make it the genotype. As I do not know the Brasilian species, I prefer to leave the question of genotype open.

[2] From description; specimens not seen.

### 1. **Anoplosiagum simplicipes** n. sp.

(Plate I, Figs. 1, 9.)

Broad, subdepressed; testaceous, head, a large discal spot on the pronotum, and the margins of the elytra piceous. Head flat, very coarsely and rather closely punctured, clypeo-frontal suture effaced, clypeus concave, transversely rectangular, front margin abruptly reflexed. Antennal club longer than stem. Pronotum transverse, sides broadly rounded, basal and apical margins entire, lateral margins finely denticulate and fimbriate with long hairs. Surface finely and rather sparsely punctured. Discal spot pentagonal, with one side applied to the anterior margin of the pronotum and the opposite angle at the middle of the basal margin, which is narrowly and irregularly infuscate. Scutellum finely and sparsely punctured. Elytra coarsely and sparsely punctured, sutural margin tumid and elevated from the scutellum to the beginning of the declivity, lateral margin fimbriate with long hairs. Greater part of the disc of each elytron pale. Pygidium finely and sparsely punctured, set with a few long hairs. Underparts moderately finely and sparsely punctured. Anterior tibia slender, upper tooth about one-fourth as long as middle one. Posterior femora inflated, longer calcar of posterior tibia acute and about as long as the first tarsal segment. Claw simple, long, and very slightly curved. Length, 7–9.5 mm. Oedeagus, Figure 1. Claw, Figure 9.

*Type locality.*—Baragua, Camaguey.

*Type and paratype.*—U. S. N. M. Cat. No. 43778.

Material examined: Four males from the type locality, taken at light May 25 and 29, 1928, June 10, 1929 (the type), and June 12, 1926, by L. C. Scaramuzza (T. P. R. F. No. 3067).

### 2. **Anoplosiagum scabrosum** n. sp.

(Plate I, Figs. 4, 10.)

*Anoplosiagum variabile* var. Γ Chevrolat, 1865, Ann. Soc. Ent. France, Ser. 4, Vol. 5, p. 22.

Form and coloration as in *A. simplicipes*, except that all tibiae and tarsi are dark. Head coarsely and cribrately punctured, clypeus flat, its anterior margin evenly curved and narrowly reflexed. (Antennae missing from type.) Pronotum sparsely and not very coarsely punctured, anterior and basal margins entire, sides subangulate at middle and very slightly sinuate behind the middle, lateral margins very finely denticulate. Scutellum almost impunctate. Elytra coarsely punctured, the punctures, especially those along the sides, partly confluent, sutural margin tumid and elevated throughout its length, discal costae faintly indicated. Pygidium not as coarsely punctured as elytra but more densely so. Underparts coarsely and rather densely punctured along the sides, much more sparsely so at middle. Anterior tibia slender, upper tooth about a third as prominent as middle tooth,

posterior femora inflated, longer calcar of posterior tibia longer than the first tarsal segment. Claw long, curved, with a minute triangular denticle near the middle. Length, 7 mm. Oedeagus, Figure 4. Claw, Figure 10.

*Type locality.*—Cabanas, Pinar del Rio.

*Type.*—U. S. N. M. Cat. No. 43779.

Material examined: One male, collected at the type locality May 21, by Messrs. Palmer and Riley.

### 3. **Anoplosiagum peltatum** n. sp.

(Plate I, Figs. 2, 5, 11.)

Oval, similar in shape to a small *Cyclocephala*, testaceous to rufotestaceous, frons and a pentagonal mark on the pronotum piceous, elytra castaneous. Frons coarsely, densely, and asperately punctured, its upper portion sparsely clothed with hairs, clypeus strongly transverse, its margin broadly rounded, more finely and sparsely punctured than frons, margin narrowly reflexed. Antennal club about as long as stem. Pronotum shining, very finely and sparsely punctured, sides somewhat dilated at middle, anterior and basal margins entire, lateral margins finely denticulate. Discal spot similar in shape to that of *A. simplicipes*, but its margin not quite so sharply defined. Scutellum sparsely punctured laterally. Elytra moderately coarsely and densely punctured, the individual punctures not confluent, sutural margin somewhat tumid and elevated, discal costae visibly differentiated from the rest of the elytral surface. Pygidium almost impunctate, the few punctures present fine and setigerous. Metathorax finely and densely, abdominal sternites coarsely and very sparsely, punctured. Upper tooth of anterior tibia very weakly developed, posterior femora not greatly inflated, longer calcar of posterior tibia hardly longer than the first tarsal segment, tarsi long and moderately thick, claw stout, bent and partially split near middle. Length, 9–11 mm. Outline of body, Figure 2. Oedeagus, Figure 5. Claw, Figure 11.

*Type locality.*—San Antonio de los Banos, Havana.

*Type and paratypes.*—U. S. N. M. Cat. No. 43780.

Material examined: One male and one female ? from the type locality collected by Jose H. Panzos; two males from Santiago de las Vegas, Havana, one collected May 29, 1927, by J. Acuna, the other July 30, 1931, by A. Otero.

These three species agree in general shape and in having a large pentagonal spot on the pronotum. By the form of the claws they may be immediately separated; furthermore, it might be noted that *A. scabrosum* can be told by its quite rough elytra.

4. **Anoplosiagum rufum** n. sp.
(Plate I, Figs. 6, 12.)

Narrowly oval, shining, uniform castaneous. Frons densely set with coarse punctures with a few fine ones intermingled. Clypeus impunctate at middle of base, coarsely and densely punctured near margins, angles rounded, margin abruptly and narrowly reflexed. Antennal club considerably longer than stem. Pronotum finely and sparsely punctured, broadly rounded at sides, anterior and basal margins entire, lateral margins finely denticulate. Scutellum finely and rather densely punctured laterally. Elytra more coarsely and densely punctured than pronotum, apices rugose, sutural margin tumid and elevated, discal costae obliterated. Pygidium densely and moderately coarsely punctured, sparsely set with long to very long hairs. Metathorax rather densely and finely punctate at sides, very sparsely so at middle, abdominal sternites sparsely punctured anteriorly, impunctate posteriorly. Upper tooth of anterior tibia well-developed but short, middle tooth about half as long as apical, which is sharply curved outward. Posterior femora hardly inflated, longer calcar of posterior tibia half again as long as first tarsal segment. Claw gently curved, slightly thickened at base and with a minute split near middle. Length, 7.5–9 mm. Oedeagus, Figure 6. Claw, Figure 12.

*Type locality.*—Jatibonico, Camaguey.

*Type and paratypes.*—U. S. N. M. Cat. No. 43781.

Material examined: The type, a male from Central Jatibonico, taken on sugar cane, May 31, 1928, by L. C. Scaramuzza (T. P. R. F. No. 3457); two specimens (one female?) from Jatibonico, in soil by L. D. Christenson (C. S. C. Ent. Nos. 5133A and 5133E).

5. **Anoplosiagum pallidulum** Blanchard.

*Anoplosiagum pallidulum* Bl., 1850, Cat. Coll. Ent. Paris, Coleopt., Vol. 1, p. 120; Chevrolat, 1865, Ann. Soc. Ent. France, Ser. 4, Vol. 5, p. 21.

Narrowly oval, hardly wider behind. Testaceous, upper surface, except flanks of pronotum, narrowly picescent. Frons lightly concave, coarsely and densely punctured, clypeus concave, moderately coarsely and not densely punctured near margin, which is narrowly and abruptly reflexed. Antennal club about as long as stem. Pronotum finely and densely punctured near anterior margin, moderately densely punctured laterally and toward basal margin, sparsely punctured on disc. Anterior and basal margins entire, lateral margins very narrowly reflexed and subentire. Scutellum sparsely punctured laterally. Elytra more coarsely and densely punctured than pronotum, apices rugulose, sutural margin slightly tumid and elevated, discal costae faint but visible. Pygidium sparsely and coarsely punctured, set with long hairs. Metathorax moderately densely and finely punctured at sides, abdominal sternites sparsely and finely punctured in anterior halves. Upper tooth of anterior tibia very weakly developed, virtually absent, posterior femora only slightly thickened, longer calcar of posterior tibia

slightly longer than the first tarsal segment. Claw nearly straight, hardly thickened basally, split just beyond middle. Length, 8–9 mm. Oedeagus, Figure 7. Claw, Figure 13.

*Type locality.*—"Cuba."

*Type.*—In the Paris Museum of Natural History.

Material examined: Twenty-five specimens, apparently all males, from Cayamas, Santa Clara, May 7–23, E. A. Schwarz.

### 6. **Anoplosiagum rutilus** (Chevrolat).

(Plate I, Figs. 3, 8, 14.)

*Clavipalpus ? rutilus* Chev., 1865, Ann. Soc. Ent. France, Ser. 4, Vol. 5, p. 22.

Elongate, very narrowly oval. Two well-marked color forms occur: (1) uniformly piceous and (2) brownish-testaceous with two discal spots on pronotum, the extreme margins of the elytra and appendages (except femora) piceous. Frons flat, with supraorbital crests slightly elevated, coarsely, densely, and evenly punctured, clypeus transverse, its margin evenly curved, punctured like frons, margin narrowly and not abruptly reflexed. Antennal club a little longer than stem. Pronotum rather coarsely and densely punctured on disc, more sparsely so at sides, sides subangulately dilated at middle, margins very narrowly reflexed and entire. Scutellum with at most a few coarse punctures, sometimes impunctate. Elytra coarsely, densely, and subrugosely punctured, sutural margin tumid and strongly elevated throughout its length, discal costae faintly indicated. Pygidium coarsely and sparsely punctured, with a short, median, longitudinal impressed line before the apex. Metathorax rather coarsely and moderately densely punctured at sides, abdominal sternites finely and sparsely punctured. Upper tooth of anterior tibia small but sharp, posterior femora not dilated, longer calcar of posterior tibia a little longer than the first tarsal segment. Claw a little curved, hardly thickened at base, the split just beyond the middle. Length, 8 mm. Outline of body, Figure 3. Oedeagus, Figure 8. Claw, Figure 14.

*Type locality.*—"Cuba."

*Type.*—In the Gundlach collection at Havana, Cuba.

Material examined: Three males from Sierra Maestra, 4,500–5,000 feet altitude, July 10–20, 1922, collected by C. H. Ballou and S. C. Bruner; one male from Pico Turquino, Sierra Maestra, same altitude, July 20, 1922, Ballou and Bruner. Through the kindness of Mr. Antonio Portuondo, Director of the Estacion Agronomica de Cuba, Mr. L. C. Scaramuzza was able to examine the type specimens as they stand in the Gundlach collection. The anterior tibia is tridentate, upper tooth small, and is without calcar. With the assignment of this species to *Anoplosiagum*, the genus *Clavipalpus* is removed from the West Indian list.

## **Phyllophaga** Harris

HARRIS, Mass. Agr. Jour. and Repository 10: 6 (note), 1826.
Genotype: *Melolontha hirticula* Knock (subsequent designation of Glasgow, 1916.)

The name *Phyllophaga* was published in 1826 by Harris in connection with the names of five previously described species. The question of its validity has been raised on several occasions. According to the International Code of Zoological Nomenclature, Article 25, "The valid name of a genus or species can be only that name under which it was first designated on the condition: (a) that this name was published and accompanied by an indication, or a definition, or a description; and (b) that the author has applied the principles of binary nomenclature." The writer considers that the citation of five previously described species must be regarded as "an indication" and that so long as the Code exists in its present wording, *Phyllophaga* Harris must be accepted as the first valid name to be proposed for this group of Scarabaeidae, *Lachnosterna* Hope, 1837, and *Ancylonycha* Bl., 1845, being synonyms.

The Cuban species all belong in the section characterized by having nine-segmented antennae. They range in size from very large (29 mm.) to small (9 mm.); the larger species are various hues of brown without any metallic luster, while at the other end of the series the species are usually bicolored and with an aeneous or rarely an opalescent sheen. The presence of lateral patches of pruinosity on the fifth sternite of the abdomen is also a character of the smaller, aeneous species. The following key to the species known to the writer which inhabit the island will, it is hoped, serve to place most of the specimens which may come to hand, and in connection with it the plates illustrating the various types of oedeagi should be used. Many species doubtless remain to be described. Previously described species which seem to be valid but specimens of which have not come to the writer's attention are listed at the end of the paper, with transcripts of the original descriptions and with remarks on their apparent relationships.

KEY TO THE CUBAN SPECIES OF *Phyllophaga*.

1. Lateral margins of pronotum coarsely crenate; size large, more than 20 mm.. 2
   Lateral margins of pronotum entire; size usually smaller, rarely over 20 mm..... 7

2. Elytron with a conspicuous fringe of long hairs which is complete to the apical angle, the hairs arising from the face of the epipleura; spur on sheath of internal sac of oedeagus with a supplementary lateral tooth (Page 182)..... **fimbriata**
   Elytron not conspicuously fringed apically, the epipleura often entirely glabrous; spur on sheath of internal sac simple..... 3
3. Epipleura reflexed, that portion at the level of the third and fourth abdominal sternites invisible from the side (Page 182)..... **expansa**
   Epipleura not reflexed, visible from side throughout its length..... 4
4. Color castaneous, epipleura feebly concave and not greatly widened behind; spur on sheath marginal, curved, and as long as width of sheath (Page 183)..... **crenaticollis**
   Color yellow-brown, epipleura notably concave and widened behind; spur on sheath not more than half as long as width of sheath..... 5
5. Pygidium irregularly and rather sparsely punctured; spur on sheath median in position and strongly hooked (Page 184)..... **onchophora**
   Pygidium evenly and rather densely punctured; spur on sheath marginal... 6
6. Epipleura glabrous or nearly so; antennal club longer than stem (Page 184)..... **schwarzi**
   Epipleura notably hairy, the hairs long at sides but becoming much shorter toward apical angle; antennal club equal to stem (Page 185) **baraguensis**
7. Metasternum densely and uniformly clad with long hairs; color generally pale brown, never with metallic luster; fifth sternite (except in *vermiculata*) without lateral pruinose spots..... 8
   Metasternum sparsely and not uniformly clad with hairs, the central portion nearly glabrous; fifth sternite with lateral pruinose spots.....21
8. Frons strongly bituberculate; length 22 mm. (Page 186)..... **tuberculifrons**
   Frons not tuberculate..... 9
9. Frons with a deep, round pit on either side of the faintly impressed median line; length 23 mm. (Page 187)..... **bicavifrons**
   Frons plane or convex, without depressions other than the faintly or strongly impressed median line.....10
10. Clypeus very densely punctured, the punctures on median portion quite fine; elytra notably widened at apical fourth; length 20–23 mm. (Page 188)..... **baracoana**
    Clypeus not very densely punctured; elytra parallel or oval; length less than 20 mm.....11
11. Upper surface densely and conspicuously hairy (Page 189)..... **puberula**
    Upper surface with at most a few scattered setae.....12
12. Frons with a short, deeply impressed median line; pronotum with a poorly defined discal piceous spot.....13
    Frons without a deeply impressed median line; pronotum unicolorous.....14
13. Pronotum coarsely, pygidium finely and sparsely punctured (Page 190) **signaticollis**
    Pronotum finely, pygidium densely punctured (Page 191)..... **santaclarae**
14. Upper surface dull, without luster; elytra pale brown, bearing punctures, each of which is set on a dark spot, the spots sometimes confluent; abdomen opalescent in certain lights (Page 195)..... **vermiculata**
    Upper surface more or less shining, uniform in color; abdomen not opalescent and without pruinose patches on fifth sternite.....15
15. Sixth antennal segment produced laterally in a ramus which is at least half as long as that of the seventh segment and which forms part of the club.....16
    Sixth antennal segment normal, not produced and not forming part of the club.....18
16. Lateral margins of elytra fimbriate; pygidium coarsely and moderately densely punctured (male) (Page 193)..... **tetracera**
    Lateral margins of elytra not fimbriate; pygidium finely and sparsely punctured.....17

17. Sixth segment of antenna almost as long as seventh; calcaria of posterior tibia very slender, the longer of which is much longer than the first tarsal segment (male) (Page 192) ..... **tenuicalcaris**
Sixth segment about half as long as seventh; calcaria of posterior tibia normally stout, the longer hardly exceeding the first tarsal segment in length (male) (Page 191) ..... **patruelis**
18. Body form slender, sides nearly parallel; pygidium moderately densely punctured in both sexes (Page 194) ..... **jaronua**
Body form robust, sides dilated toward middle of length ..... 19
19. Pygidium at middle moderately densely punctured (male) (Page 194) **cubana**
Pygidium very sparsely punctured ..... 20
20. Pygidium nearly flat (female) (Page 191) ..... **patruelis**
Pygidium strongly convex before apex (female) (Page 194) ..... **cubana**
21. All or a greater part of the upper surface opaque, pruinose ..... 22
Entire upper surface shining ..... 26
22. Clypeus and frons in same plane; elytra dull and pruinose except for subapical callosities which are shining ..... 23
Plane of clypeus elevated over plane of frons ..... 24
23. Legs normally stout; color uniform piceous, punctures of metathorax and sides of abdominal sternites similar in size and density (Page 197) **cardini**
Legs unusually slender, the hind femora not conspicuously swollen; color pale brown dotted above with darker, punctures of abdominal sternites notably finer and denser than those of metathorax (Page 196) **speculifera**
24. Elytra opaque except for areas around humeral calli and lateral subapical areas, which are shining (female) (Page 197) ..... **analis**
Elytra entirely opaque ..... 25
25. Length 13–14 mm.; clypeus narrowly reflexed, punctures of head coarse; anterior angles of pronotum produced (male) (Page 197) ..... **analis**
Length 11 mm.; punctures of head fine; anterior angles of pronotum not produced (Page 199) ..... **imitatrix**
26. Labrum cordate with apex up, evenly and rather deeply concave, its surface shining and devoid of punctures, its upper margin set with about twelve stiff and rather long setae, its lower margin fringed with shorter hairs (Page 199) ..... **labrata**
Labrum normal in form, bicallose, the callosities irregularly punctate ..... 27
27. Apex of middle tooth of anterior tibia equidistant from apices of basal and apical teeth ..... 28
Middle tooth noticeably nearer apical than basal tooth ..... 29
28. Basal tooth in male feebly developed; clypeus flat, only anterior fourth reflexed (Page 200) ..... **suturalis**
Basal tooth in both sexes well developed; clypeus concave, strongly reflexed in its anterior half (Page 201) ..... **aeneotincta**
29. Color uniform piceous (castaneous in teneral specimens); sides of clypeus not strongly converging anteriorly, median indentation feeble (Page 201) ..... **dissimilis**
Elytra pale with the suture broadly or narrowly dark; sides of clypeus strongly converging anteriorly, median indentation moderate to strong ..... 30
30. Sutural stripe narrow, including only the sutural beads ..... 31
Sutural stripe broad, including greater part of disc of elytra ..... 32
31. Clypeus not strongly indented at middle; pronotum rather strongly punctured (Page 202) ..... **microsoma**
Clypeus strongly indented, the halves evenly and strongly curved; pronotum more densely punctured (Page )203 ..... **bruneri**
32. Sutural bead strongly tumid and elevated; fifth sternite laterally impressed on basal half (Page 204) ..... **alquizara**
Sutural bead not strongly elevated over level of disc; fifth sternite not impressed laterally (Page 204) ..... **aeruginosa**

1. **Phyllophaga fimbriata** n. sp.
(Plate II, Fig. 15.)

Very large, oblong, slightly wider behind, shining, dark brown, head piceous, pronotum castaneous, elytra slightly paler than pronotum. Head coarsely and closely punctured, clypeo-frontal suture sharply defined, clypeus less densely punctured than frons, median indentation moderately deep, angulate, margins evenly rounded, broadly reflexed. Pronotum coarsely but sparsely punctured, sides subangulate at middle, lateral margins reflexed and strongly crenate, near the anterior and basal angles the margin becoming explanate, anterior and basal margins narrow and complete. Scutellum with a few coarse punctures. Elytra sparsely and finely punctured, sutural margins tumid and strongly elevated, discal costae faintly indicated, epipleura strongly narrowed at level of posterior coxae, strongly widened at level of third and fourth abdominal sternites, thickly set with long brown hairs throughout length. Pygidium moderately densely and finely punctured, with a short brown hair arising from each puncture. Metathorax closely punctured and densely hairy. First four sternites sparsely punctured, fifth sternite more coarsely and densely punctured. Upper tooth of anterior tibia well developed. Longer of calcaria of posterior tibia slightly flexed near apex, as long as the first tarsal segment with its apical spine. Claw heavy, strongly curved, the median tooth stronger than apical portion. Length, 25–29 mm. Oedeagus, Figure 15.

*Type locality.*—Jaronu, Camaguey.

*Type and paratypes.*—U. S. N. M. Cat. No. 43782.

Material examined: A male, the type, collected April 29, 1928, at light, by H. K. Plank (T. P. R. F. No. 2386) and two males and one female collected May 12–20, 1926, by B. T. Barreto.

The spur on the sheath of the internal sac of the oedeagus is submarginal in position and is compound, having a supplementary tooth on its inner aspect at about the middle of the length.

2. **Phyllophaga expansa** n. sp.
(Plate II, Fig. 16.)

Very large, oblong, strongly widened behind, nearly uniformly pale brown, head castaneous. Frons and basal part of clypeus coarsely and densely, apical part of clypeus more sparsely, punctured. Median indentation moderately deep but not sharply angulate, margin strongly reflexed. Pronotum sparsely, rather coarsely and irregularly punctured, sides subangulate at middle, lateral margins strongly crenate and almost evenly reflexed throughout length, anterior and basal margins complete and narrow. Scutellum with a few scattered punctures along the lateral margins. Elytra finely and rather sparsely punctured, sutural margins

tumid and strongly elevated, discal costae very faintly indicated. Epipleura strongly widened at apical fourth, strongly ascending internally so that the surface of the epipleura itself is invisible from the side. Pygidium very finely and moderately densely punctured, each puncture bearing a short hair. Underparts finely and moderately densely punctured, metathorax densely hairy. Upper tooth of anterior tibia well developed. Longer of the calcaria of the posterior tibia slightly bent in both lateral and dorsoventral planes, about as long as first tarsal segment with its apical spine. Claw as in *P. fimbriata* Chpn. Length, 23–26 mm. Oedeagus, Figure 16.

*Type locality.*—Constancia, Santa Clara.

*Type and paratypes.*—U. S. N. M. Cat. No. 43783.

Material examined: One male, the type, and four males from the type locality, collected May 14, by J. F. Merrill.

The spur on the sheath of the internal sac is marginal in position and is quite short and somewhat hooked.

### 3. **Phyllophaga crenaticollis** (Blanchard.)

(Plate II, Fig. 17.)

*Ancylonycha crenaticollis* Bl., 1850, Cat. Coll. Ent. Paris, Coleopt., Vol. 1, p. 137; Burmeister, 1855, Handb. Ent., Vol. 4, Part 2, p. 336.
*Ancylonycha crenatocollis* Chevrolat, 1865, Ann. Soc. Ent. France, Ser. 4, Vol. 5, p. 23. (Typographical error.)

Large, oblong, slightly widened behind, underparts yellow-brown, upper surfaces rufocastaneous. Frons coarsely and densely punctured, clypeus less densely so, median indentation deep and subangulate, margin strongly reflexed. Pronotum moderately coarsely and sparsely punctured, sides obtusely angulate at middle, lateral margins strongly crenate and narrowly reflexed except near anterior angles where the reflexed margin becomes wider, anterior angles right, posterior angles obtuse, anterior margin entire, basal margin broken across disc. Scutellum with a few scattered punctures on posterior part. Elytra coarsely wrinkled, sutural margins tumid and strongly elevated, discal costae faintly indicated, finely and sparsely punctured. Epipleura rather narrow, not strongly widened posteriorly, sparsely hairy. Pygidium finely and densely punctured, each puncture bearing a short hair. Metathorax finely and densely, posterior coxal plates and abdominal sternites finely and sparsely, punctured. Upper tooth of anterior tibia strongly developed. Longer of the calcaria of posterior tibia as long as first tarsal segment, including its apical spine. Claw as in *P. fimbriata* Chpn. Length, 19.5–24 mm. Oedeagus, Figure 17.

*Type locality.*—"Cuba."

*Type.*—In the Paris Museum of Natural History.

Material examined: Two males and one female from Vedado, Havana, collected June 16, 1927, at light, by L. Scaramuzza (T. P. R. F. No. 3098); one male and one female from Bolondron,

Matanzas (E. E. A. de Cuba, No. 9184); one female from "La Miranda," Rio Almendares, Havana, July, 1916; six males from Havana, May 1–19, 1926, September 8, 1927, collected by S. C. Bruner.

The spur on the sheath of the internal sac is marginal in position, long and curved.

### 4. **Phyllophaga onchophora** n. sp.

(Plate II, Fig. 18.)

Large, oblong, slightly wider behind, castaneous to flavocastaneous, head slightly darker. Head densely and moderately finely punctured, clypeus with median indentation broad and subangulate, margin narrowly but not abruptly reflexed. Pronotum more finely and much more sparsely punctured than head, the punctures fairly evenly distributed, sides subangulate at middle, lateral margins strongly crenate, narrowly reflexed, slightly explanate at anterior angles. Anterior angles right, basal angles obtuse, anterior and basal margins complete and narrow. Scutellum with a few large punctures at sides. Elytra very finely and sparsely punctured, sutural margins tumid and elevated, discal costae very faintly indicated. Epipleura not greatly widened posteriorly, sparsely hairy. Pygidium very finely and sparsely punctured, each puncture bearing a short hair. Metathorax moderately finely and quite densely punctured, posterior coxal plates more coarsely and sparsely so. Abdominal sternites very finely and quite sparsely punctured. Upper tooth of anterior tibia strongly developed. Longer of the calcaria of the posterior tibia longer than the first tarsal segment with its apical spine. Claw as in *P. fimbriata* Chpn. Length, 23–25.5 mm. Oedeagus, Figure 18.

*Type locality.*—Paso Estancia, Oriente.

*Type and paratypes.*—U. S. N. M. Cat. No. 43784.

Material examined: One male, the type, from Paso Estancia, March 16; one male and one female from Trinidad, Santa Clara, April and May, 1912, J. F. Merrill; one male from Santiago de las Vegas, Havana; one male from Perico, Matanzas, April, 1922, B. T. Barreto.

In this species, the spur on the sheath of the internal sac is central in position, short and strongly curved.

### 5. **Phyllophaga schwarzi** n. sp.

(Plate II, Fig. 19.)

Large, oblong, slightly wider behind, light piceous to yellow-brown, head only slightly darker. Head evenly, rather coarsely and densely punctured, median indentation of clypeus deep and angulate, sides broadly and evenly rounded, margin broadly and sharply reflexed. Pronotum as coarsely but more sparsely punctured than head, sides

subangulate at middle, lateral margins reflexed and strongly crenate, the reflexed portion narrow and widened slightly only near anterior angles, which are a little greater than right. Basal angles rounded. Anterior and basal margins narrow, basal margin broken across disc. Scutellum impunctate or with a few large, scattered punctures. Elytra finely and sparsely punctured, sutural margin tumid and elevated, first discal costa fairly well defined, second faintly indicated, epipleura widened posteriorly, visible from side, very sparsely hairy. Pygidium moderately coarsely and quite densely punctured, set with short hairs. Metathorax and abdominal sternites finely, posterior coxal plates more coarsely, punctured. Upper tooth of anterior tibia well developed, longer calcar of posterior tibia exceeding first tarsal segment (with apical spine) in length. Claw as in *P. fimbriata* Chpn. Length, 24–25 mm. Oedeagus, Figure 19.

*Type locality.*—Cayamas, Santa Clara.

*Type and paratypes.*—U. S. N. M. Cat. No. 43785.

Material examined: Ten males from Cayamas, May 6 to June 4, E. A. Schwarz, collector.

The oedeagi of this and the following species are quite similar to that of *P. expansa* Chpn. Because of the external differences, the writer considers it necessary to treat the three forms as distinct. Although a small difference, it might be noted that in the case of *P. schwarzi* the spine is an outgrowth of the tumid margin of the sheath, whereas in *P. baraguensis* the spine is submarginal in position and arises from the outer surface of the sheath just below the tumid margin. In *P. expansa* the position of the spine is as in *P. baraguensis*.

### 6. **Phyllophaga baraguensis** n. sp.

(Plate II, Fig. 20.)

Large, oblong, somewhat widened behind, yellowish-brown to yellowish-castaneous, head and sometimes pronotum darker. Head as coarsely but less densely punctured than in *P. schwarzi*, median indentation of clypeus deep and subacutely angulate, but not as deep as in *P. schwarzi*, margin strongly but less abruptly reflexed than in that species. Pronotum rather finely and quite sparsely punctured, sides subangulate at middle, lateral margins as in *P. schwarzi*, anterior and basal margins entire (in one specimen the basal margin is very narrowly broken across the disc). Scutellum impunctate or with a few coarse punctures. Elytra finely and sparsely punctured, sutural margin tumid and elevated, discal costae obsolete, epipleura widened posteriorly, densely set with moderately long hairs in the posterior half, except that as the apex is approached the hairs become short and sparse. Pygidium finely and rather densely punctured, set with short hairs. Metathorax, posterior coxal plates, and abdominal sternites finely and rather densely, the abdominal sternites more sparsely, punctured. Upper tooth of anterior

tibia very strongly developed, longer calcar of posterior tibia hardly longer than first tarsal segment with its apical spine. Claw as in *P. fimbriata* Chpn. Length, 24.5–27 mm. Oedeagus, Figure 20.

*Type locality.*—Baragua, Camaguey.

*Type and paratypes.*—U. S. N. M. Cat. No. 43786.

Material examined: A male, the type, and four males and seven females from the type locality. The type and three paratypes were taken at light April 29, 1925, by D. L. Van Dine (T. P. R. F. No. 1037); three paratypes taken at light April 30, 1925, by Van Dine (T. P. R. F. No. 1056); one paratype taken similarly May 1, 1925 (T. P. R. F. No. 1069); one paratype taken May 7, 1926, and one paratype taken May 17, 1927, by L. Scaramuzza (T. P. R. F. No. 1037); one paratype collected June 15, 1927, by C. F. Stahl; one paratype taken June 8, 1931, by L. D. Christenson (C. S. C. No. 5346).

Besides the characters mentioned in the key, this species may be distinguished from *P. schwarzi* by the fact that the punctation of the posterior coxal plate is similar to that of the metathorax in the present species, while in *P. schwarzi* the coxal plate is much more coarsely punctured than is the metathorax.

**Phyllophaga** sp.

A single broken female of a large *Phyllophaga* having the lateral margins of the pronotum coarsely crenate is before the writer. It was collected at Santiago, [Oriente?]. While it does not appear to be the same as any of the species described above, in the absence of additional material in better condition it is left without name.

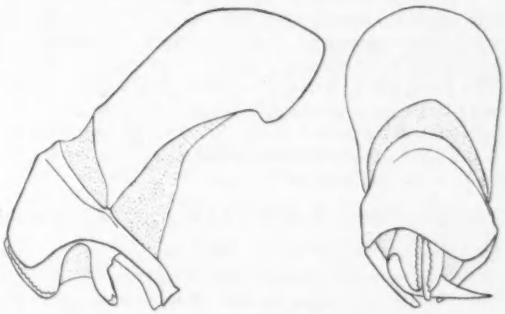
### 7. **Phyllophaga tuberculifrons** (Chevrolat).

(Text Fig. 1.)

*Ancylonycha tuberculifrons* Chevr., 1865, Ann. Soc. Ent. France, Ser. 4, Vol. 5, p. 23.

Large, yellowish- to reddish-brown, head piceous. Frons strongly bituberculate with a median longitudinal impression. The portion immediately surrounding the tubercles is rather densely punctured, and the rest of the frons is virtually impunctate, with a more or less reniform depression adjacent to each eye. Clypeus broadly reflexed, with a sharp angulate median indentation, surface sparsely and vaguely punctured. Pronotum sparsely and irregularly punctured, more densely so at sides, with a median narrow longitudinal smooth impunctate area on posterior half. Lateral margins slightly reflexed, smooth and entire. Scutellum sparsely and irregularly punctured. Elytra finely and moderately densely punctured, sutural margin tumid and

elevated, discal costae virtually absent, epipleura narrow and of uniform width throughout their length. Pygidium (female) triangular, coarsely and moderately densely punctured, unituberculate before apex, the tubercle not sharply set off from the surrounding surface, apical rim hairy. Metathorax densely and finely punctured, abdominal sternites finely punctured except for lateral areas on fifth where the punctures are coarse and somewhat asperate. Longer calcar of posterior tibia (female) long, narrow and gently curved. Claw with tooth large, a little beyond the middle. Length, 22 mm. Oedeagus, Text Figure 1.



TEXT FIG. 1. *Phyllophaga tuberculifrons* Chevr.
From Cotype in P. A. N. S., November, 1931, E. A. C.

*Type locality.*—"Cuba."

*Type.*—Cotypes possibly in the collection of J. Moser, Berlin; and in the Poey collection, Academy of Natural Sciences, Philadelphia.

Material examined: One male, "Cuba," Poey collection; one female from Santo Tomas (Zapata), Santa Clara, May 5–9, 1927, S. C. Bruner and J. Acuna.

This species is remarkable for the tuberculate frons and more especially because of the fact that the calcaria of the posterior tibia of the female are not of the usual type for the female sex, but are slender as in the male. The specimen before me has been dissected and is a female beyond question.

### 8. **Phyllophaga bicavifrons** n. sp.

Large, dark yellowish-brown, head and pronotum reddish-brown. Frons irregularly and coarsely punctured, with a small circular depression on either side of the slightly impressed median line, the punctures near the depressions finer and more densely placed. Clypeus finely punctured at middle, more coarsely so at sides, margin gradually

and rather broadly reflexed, median indentation broad, rather shallow and sharply angulate. Sixth antennal segment slightly prolonged, wider than fifth. Pronotum sparsely and irregularly punctured, sides feebly angulated, lateral margins smooth and entire, anterior angles sharp and somewhat more than right, basal angles rounded, anterior and basal margins complete. Scutellum coarsely and sparsely punctured. Elytra somewhat wrinkled on disc, smooth at sides, sutural margin tumid and slightly elevated, discal costae faintly indicated, surface finely and rather densely punctured, epipleura narrow, hardly widened posteriorly. Pygidium (female) subtriangular, its apex truncate and produced in a narrow, transverse, reflexed lip. Metathorax densely, posterior coxal plates sparsely, both coarsely, punctured, abdominal sternites finely and very sparsely punctured except laterally on the first where the punctures are quite densely placed. Upper tooth of anterior tibia not strongly produced, calcaria of posterior tibia (female) rather narrow, but of the usual form, first tarsal segment shorter than longer calcar. Tooth of tarsal claw prominent, stouter and longer than apical portion of claw. Length, 24 mm.

*Type locality.*—Sierra Maestra, 1,070–1,350 meters.

*Type.*—U. S. N. M. Cat. No. 43787.

Material examined: A single female from the above locality, collected July 10–20, 1922, by C. H. Ballou and S. C. Bruner.

It is possible that the male of this species will prove to be related to the *P. patruelis* group. In the female the development of the antenna is similar to that in females of that group. The species is distinguished from all other known Cuban species by the peculiar developments of the head and pygidium.

### 9. **Phyllophaga baracoana** n. sp.

(Plate II, Fig. 22.)

Large, uniform yellowish- to reddish-brown, except for the head, which is darker. Frons and clypeus closely and coarsely punctured, the punctures of the clypeus finer than those of frons, margin of clypeus broadly reflexed, median indentation broad and rather deep, not angulate. Pronotum coarsely and rather sparsely punctured, sides feebly sinuate behind the rounded median angulation, lateral margin entire, narrowly reflexed, anterior angles hardly produced, posterior angles rounded, anterior margin entire, basal margin obsolete. Scutellum coarsely and moderately densely punctured except for a median impunctate area. Elytra moderately and coarsely and rather densely punctured, sutural margin tumid and elevated, discal costae virtually absent, epipleura narrow, not widened behind. Pygidium irregularly set with a mixture of large and small punctures. Metathorax and posterior coxal plates densely and rather coarsely punctured, abdominal sternites sparsely and finely punctured, the punctures more densely placed laterally on the first and fifth. Upper tooth of anterior tibia

well developed, longer calcar of posterior tibia slender and notably longer than the first tarsal segment. Claw strongly curved, the tooth stronger and thicker than the apical portion. Length, 23 mm. Oedeagus, Figure 22.

*Type locality.*—Baracoa, Oriente.

*Type and paratype.*—U. S. N. M. Cat. No. 43788.

Material examined: One male, the type, collected April, 1916, by P. Cardin and received from S. C. Bruner; one female collected February, 1907, (collector not stated).

The paratype female resembles the male closely in habitus and punctation, but is smaller, being but 20 mm. in length. The oedeagus shows a degree of asymmetry unusual in the Cuban species.

### 10. **Phyllophaga puberula** (Du Val.)

(Plate II, Fig. 21.)

*Ancylonycha puberula* Du Val, 1856, in Sagra, Hist. Cuba, Vol. 7, p. 56; Chevrolat, 1865, Ann. Soc. Ent. France, Ser. 4, Vol. 5, p. 24.

Medium, yellow- to reddish-brown, head slightly darker. Frons coarsely and moderately densely punctured, sparsely hairy. Clypeus more finely and less densely punctured, narrowly reflexed, median indentation shallow and broad. Pronotum sparsely and rather finely punctured, the punctures sparser at sides, lateral margins very narrowly reflexed and subcrenulate, anterior angles acute, basal angles rounded, surface sparsely clad with erect hairs, anterior margin present, basal margin obsolete. Scutellum smooth medianly, rather coarsely punctured laterally. Elytra smooth, sutural margin tumid and slightly elevated, discal costae virtually absent, surface finely and rather densely punctured, a short or occasionally a longer hair arising from each puncture. Pygidium sparsely and finely punctured. Metathorax finely, densely and regularly punctured, posterior coxal plates sparsely and more coarsely punctured, abdominal sternites finely and rather sparsely punctured, the punctures more dense laterally on the second sternite. Anterior tibia slender, upper tooth about half as large and prominent as the median. Longer calcar of posterior tibia much longer than the first tarsal segment, which is not prolonged apically in a spine. Claw thickened basally, the tooth, which is just beyond middle, larger than apical portion. Length, 12–16 mm. Oedeagus, Figure 21.

*Type locality.*—"Cuba."

*Type.*—Possibly in the Berlin Zoological Museum.

Material examined: Seven males from Cabanas, Pinar del Rio, May 16–21, Palmer and Riley; five males and two females from Santiago de las Vegas, Havana, S. C. Bruner (E. E. A. de Cuba, Nos. 6100, 9097); one male from Alquizar, Havana, June 8, 1927, at light, L. Scaramuzza (T. P. R. F. No. 3060); one male and four females from Hato Nuevo, Matanzas, S. C.

Bruner (E. E. A. de Cuba, No. 9167); one male and five females from Cayamas, Santa Clara, May 7 to June 8, E. A. Schwarz; two males and two females from same locality, April 17, 1905, G. Dimmock; two males from Constancia, Santa Clara, May 14, J. F. Merrill; one male from Trinidad, Santa Clara, April-May, 1912, J. F. Merrill; six males and five females from Baragua, Camaguey, April 29 to July 26, at light, Scaramuzza, Van Dine, Stahl, and Bruner (T. P. R. F. Nos. 1038, 1106, 3060); three males from Jaronu, Camaguey, March 13 to April 27, L. C. Scaramuzza (C. S. C. No. 3986).

This species is immediately distinguished from all other Cuban species of the genus by the finely crenulate or subcrenulate margin of the pronotum and by the pubescent upper surface. No specimens have yet been seen from Oriente though the species probably occurs in the western part of that province.

11. **Phyllophaga signaticollis** (Burmeister).
(Plate II, Fig. 23.)

*Ancylonycha signaticollis* Burm., 1855, Handb. Ent., Vol. 4, Pt. 2, p. 337.
*Ancylonycha confusa* Du Val, 1856, in Sagra, Hist. Cuba, Vol. 7, p. 56; Chevrolat, 1865, Ann. Soc. Ent. France, Ser. 4, Vol. 5, p. 25.

Medium, yellowish-brown, head and transverse spot near anterior margin on pronotum (rarely almost absent) piceous. Head coarsely and rather sparsely punctured, the median line of frons strongly impressed, clypeus much more densely punctured, its margin abruptly reflexed, median indentation shallow and rounded. Pronotum moderately coarsely and sparsely punctured, the punctures still more sparse toward the basal angles, sides medianly subangulate, lateral margin entire, anterior angles not prolonged, basal angles rounded, anterior margin entire, basal margin absent across disc. Scutellum sparsely punctured laterally. Elytra more finely and densely punctured than the pronotum, sutural margin tumid and slightly elevated, discal costae obliterated, epipleura narrow, parallel. Metathorax finely and densely punctured, posterior coxal plates and abdominal sternites sparsely punctured except for lateral portions of fifth which are densely punctured. Upper tooth of anterior tibia well developed, longer calcar of posterior tibia much longer than first tarsal segment. Claw with strong tooth at about middle. Length, 14–15 mm. Oedeagus, Figure 23.

*Type locality.*—"Cuba."

*Type.*—Of *signaticollis*, probably at Halle; of *confusa*, possibly in the Berlin Zoological Museum.

Material examined: Four males from Havana, May 14 to October 22, S. C. Bruner; two females from Bejucal, Havana, June 7, 1926, F. Menocal; one male from Santiago de las Vegas,

Havana, June 7, 1927; one female from Hoyo Colorado, Havana, June 9, 1924, C. Enamorado; one male from Alquizar, Havana, June 8, 1927, at light, L. Scaramuzza (T. P. R. F. No. 1057); and one female from Cayamas, Santa Clara, June 11, E. A. Schwarz.

In the case of fully colored specimens this species can not be confused with any species except the next, from which it may be distinguished by the characters given in the key and by the form of the oedeagus. The specimen mentioned above as from Alquizar has the thoracic marking almost obliterated.

12. **Phyllophaga santaclarae** n. sp.
(Plate II, Fig. 24.)

Medium, yellowish-brown, head and a nebulous patch on the pronotum piceous. Head sparsely and rather coarsely punctured, median line feebly impressed, clypeus slightly more densely punctured than frons, margin narrowly and abruptly reflexed, median indentation very broad and shallow, almost obsolete. Pronotum more sparsely punctured than head, sides subangulate, lateral margins entire, anterior angles not produced, basal angles distinct, but rounded at their apices, anterior margin entire, basal margin indicated at sides. On the disc, slightly before the middle, there is an ill-defined transverse dark blotch. Scutellum rather finely punctured at sides. Elytra more finely and densely punctured than pronotum, sutural margin smooth, hardly elevated, and not distinctly set off from the rest of the elytron, discal costae obliterated, epipleura narrow, parallel. Metathorax densely, posterior coxal plates very sparsely, punctured. Abdominal sternites much more finely and rather sparsely punctured, except that the lateral fields of the first and second are densely punctured. Upper tooth of anterior tibia weakly developed, longer calcar of posterior tibia much longer than first tarsal segment. Claw long, median tooth much stouter than apical portion. Length, 16 mm. Oedeagus, Figure 24.

*Type locality.*—Manacas, Santa Clara.

*Type.*—U. S. N. M. Cat. No. 43789.

Material examined: One male, the type, collected at the above place on June 7, 1930, by S. C. Bruner.

13. **Phyllophaga patruelis** (Chevrolat).
(Plate II, Fig. 26.)

*Ancylonycha patruelis* Chevr., 1865, Ann. Soc. Ent. France, Ser. 4, Vol. 5, p. 25.

Medium, yellowish-brown, pronotum rufotestaceous, head piceous. Frons and clypeus evenly, coarsely and densely punctured. Clypeus gradually reflexed, median indentation shallow, not sharply angulate. Antenna rufotestaceous with pale yellow club; male with fifth segment triangular with apex of lateral prolongation directed basad, sixth segment a little more than half as long as seventh; female with fifth segment in form of an equilateral triangle, apex directed outward, sixth segment

a little more prolonged laterally than fifth and hardly half as long as seventh. Pronotum evenly, coarsely, but quite sparsely punctured, sides subangulate at middle, lateral margins entire except for two or three notches, very narrowly reflexed. Scutellum very sparsely punctured at sides. Elytra rather more finely and densely punctured than pronotum, sutural margin tumid and slightly elevated, discal costae obsolete, epipleura narrow, nearly parallel. Pygidium sparsely punctured, moderately coarsely in male, much more finely so in female. Metathorax very finely and densely punctured, posterior coxal plates and abdominal sternites sparsely punctured. Upper tooth of anterior tibia moderately developed, longer calcar of posterior tibia about as long as first tarsal segment. Claw long and slender, the median tooth not longer but stouter than the apical portion. Length, 14.5–17 mm. Oedeagus, Figure 26.

*Type locality.*—"Cuba."

*Type.*—Possibly in the collection of J. Moser, Berlin.

Material examined: Twenty-two males and eleven females from Cayamas, Santa Clara, May 5–7, E. A. Schwarz; one male from same locality, April 17, 1905, G. Dimmock; fifteen males and three females from Constancia, Santa Clara, May 14, J. F. Merrill; four males and one female from Trinidad, Santa Clara, April-May, 1912, J. F. Merrill; one male and seven females from Baragua, Camaguey, April 29 to May 17, D. L. Van Dine and L. C. Scaramuzza (T. P. R. F. Nos. 1038, 1057, 1070).

The writer is not entirely satisfied with the association of the above described specimens with Chevrolat's name. The species here characterized is apparently common and widely distributed and fits the description of *P. patruelis* Chevr. in most respects. It lacks a transverse ridge on the head, however, and displays an aberrant antennal structure. To add to the complication, the material before Chevrolat evidently represented two or more species.

### 14. **Phyllophaga tenuicalcaris** n. sp.

(Plate II, Fig. 29.)

Similar in size and coloration to *P. patruelis* Chevr. Frons much more sparsely, clypeus a little more sparsely punctured than in that species. Antenna with sixth segment almost as long as seventh. Pronotum slightly more densely punctured anteriorly, sides subangulate just behind the middle, lateral margins more strongly reflexed, especially in anterior half. Scutellum sparsely punctured laterally. Elytra as in *P. patruelis* Chevr. Pygidium more finely and sparsely punctured than in that species. Metathorax densely and finely, posterior coxal plates coarsely and sparsely, punctured. Abdominal sternites strongly,

rather densely and aciculately punctured in the median field. Upper tooth of anterior tibia weakly developed, longer calcar of posterior tibia very slender and elongate, half again as long as first segment of tarsus. Claw as in *P. patruelis* Chevr. Length, 15 mm. Oedeagus, Figure 29.

*Type locality.*—Galbis, Camaguey.

*Type.*—U. S. N. M. Cat. No. 43790.

Material examined: One male, the type, from the above locality, collected by Miss Zoe McLaughlin and presented to the Museum by Professor P. W. Fattig.

In addition to the characters mentioned in the key, this species may be separated from its near relatives by the aciculate punctures of the abdominal sternites and by the more sharply reflexed margin of the pronotum.

15. **Phyllophaga tetracera** n. sp.

(Plate II, Fig. 25.)

Above medium, yellowish-brown, pronotum and scutellum rufotestaceous, head piceous. Frons moderately coarsely and sparsely, clypeus more densely punctured, margin gradually reflexed, median indentation shallow, not sharply angulate. Antenna with the lateral prolongation of the fifth segment half as long as that of the sixth, which in turn is half as long as that of the seventh. Pronotum sparsely and moderately coarsely punctured, sides feebly sinuate both before and behind the very rounded median dilation, lateral margins entire and very narrowly reflexed, anterior angles distinct, posterior angles broadly rounded, anterior margin entire, basal margin indicated at sides of base. Scutellum punctured except for a small central area. Elytra finely and rather sparsely punctured, sutural margin tumid and elevated, discal costae only faintly indicated, epipleura narrow, densely fimbriate in posterior half of lateral extent, not fimbriate apically. Pygidium coarsely and rather densely punctured. Metathorax densely and finely, posterior coxal plates sparsely and coarsely punctured. Abdominal sternites finely and rather less densely punctured than metathorax, except at sides of first and second, where the punctures are unusually fine and dense. Upper tooth of anterior tibia well-developed, longer calcar of posterior tibia but little longer than the first tarsal segment. Claw with a prominent triangular median tooth, apical portion much more slender than tooth. Length, 19 mm. Oedeagus, Figure 25.

*Type locality.*—Seboruco, Oriente.

*Type.*—U. S. N. M. Cat. No. 43791.

Material examined: A single male, the type, collected at Seboruco, July 14–18, 1927, by S. C. Bruner.

The formation of the sheath of the internal sac and of other parts of the oedeagus as well as the fimbriate epipleurae indicate a certain relationship to the species of the *crenaticollis* group.

16. **Phyllophaga cubana** n. sp.
(Plate II, Fig. 27.)

Medium, yellowish-brown, pronotum ferruginous, head piceous. Frons and clypeus coarsely but not densely punctured, margin of clypeus broadly but not at all abruptly reflexed, median indentation shallow. Pronotum sparsely and irregularly punctured, sides subangulate, lateral margins entire and narrowly reflexed, anterior angles acute, hardly produced, posterior angles rounded, anterior margin entire, basal margin broken only across disc. Scutellum with but a few coarse punctures laterally. Elytra with punctures similar to those of pronotum, sutural margin tumid and elevated, discal costae obliterated, epipleura very narrow, parallel. Pygidium sparsely and very irregularly punctured, laterally almost impunctate. Metathorax densely and moderately coarsely punctured, posterior coxal plates less densely so. First abdominal sternite densely and finely, other sternites sparsely and finely, punctured. Upper tooth of anterior tibia well developed, longer calcar of posterior tibia a little longer than first tarsal segment. Claw not strongly curved, tooth strong, heavier than the apical portion. Length, 15 mm. Oedeagus, Figure 27.

*Type locality.*—Baragua, Camaguey.

*Type and paratype.*—U. S. N. M. Cat. No. 43792.

Material examined: A male, the type, and a female, from Baragua, collected May 17 and June 8 at light by L. C. Scaramuzza (T. P. R. F. No. 1057).

This species resembles *P. patruelis* Chevr. quite closely but has a normal development of the antennal club, is rather more oval in shape, and has an oedeagus of entirely different pattern. It is, however, more closely related to the next species.

17. **Phyllophaga jaronua** n. sp.
(Plate II, Fig. 28.)

Submedian, nearly cylindrical, pale reddish-brown, head slightly darker. Frons rather deeply and sparsely punctured on upper half, the punctures near middle less coarse than those at sides, portion near clypeo-frontal suture almost impunctate. Clypeus with a shallow median indentation, sides evenly but feebly curved, margin gradually reflexed, surface coarsely, evenly, and rather sparsely punctured. Pronotum more sparsely punctured than clypeus, sides subangulately dilated at middle, lateral margins fine and entire, anterior angles well-defined, but not produced, basal angles rounded, anterior margin entire, basal margin broken across disc. Scutellum sparsely punctured. Elytra more densely punctured than pronotum, sutural margin tumid and elevated, discal costae obliterated, epipleura very narrow. Pygidium coarsely and evenly punctured. Metathorax moderately densely and finely punctured. Posterior coxal plates and abdominal sternites sparsely punctured, the punctures on the abdomen finer than those on the plates. Upper tooth of anterior tibia well-defined, the tibia itself

rather slender. Longer of the calcaria of the posterior tibia about equal in length to the first tarsal segment. Claw rather long and slender, nearly straight, the median tooth broad and considerably stouter than apical portion. Length, 14–15.5 mm. Oedeagus, Figure 28.

*Type locality.*—Jaronu, Camaguey.

*Type and paratype.*—U. S. N. M. Cat. No. 43793.

Material examined: A male, the type, and one male and three females, paratypes, from Jaronu, collected April 27 to May 18, by B. T. Barreto and L. C. Scaramuzza (C. S. C. Ent. Nos. 5145, 5146).

About the size and shape of *P. parallela* Blanchard, which I have not seen, but differing from that species in the entire pronotal margin and in the texture of the integuments. The species is also closely related to *P. cubana* Chpn., but differs from it in the form of the body, in the dense punctation of the female pygidium, and in the conformation of parts of the oedeagus.

### 18. **Phyllophaga vermiculata** n. sp.

(Plate II, Fig. 30.)

Medium, pale reddish- to yellowish-brown, elytra vermiculate with darker brown, head and pronotum piceous. Frons opaque, coarsely and rather sparsely punctured, median line just visibly impressed. Clypeus shining, narrow, very coarsely and densely punctured, margin narrowly and abruptly reflexed, median indentation wide and rather deep, subangulate. Antennal club slightly shorter than stem. Pronotum opaque, slightly iridescent, rather finely and sparsely punctured, sides subangulately produced at middle, margins entire (except basal, which is broken across disc), anterior and basal angles narrowly rounded. Scutellum opaque, iridescent, sparsely punctured. Elytra opaque, rather finely and irregularly punctured, sutural margin not noticeably differentiated from the rest of the elytron, pale brown, each puncture on a small dark brown spot, the spots coalescing where the punctures are close one to another. Epipleura narrow, not widened posteriorly. Pygidium opaque, irregularly and finely punctured. Posterior coxal plates rather coarsely and sparsely punctured, metathorax and abdominal sternites finely punctured, the former densely, the latter very sparsely so. Fifth abdominal sternite with lateral pruinose patches. Upper tooth of anterior tibia well developed, middle tooth much nearer apical tooth than to upper. Longer calcar of posterior tibia long, slender, and blunt at tip, much longer than the first tarsal segment. Claw enlarged at base, tooth median, stout, stronger than apical portion. Length, 14.5 mm. Oedeagus, Figure 30.

*Type locality.*—Sierra Maestra, Palma Maeha.

*Type.*—U. S. N. M. Cat. No. 43794.

Material examined: One male, the type, collected at the

above locality at an altitude of between 1,070 and 1,330 meters, July 10–20, 1922, by C. H. Ballou and S. C. Bruner.

The hairy metathorax and the lack of metallic luster ally this species to those described above; the presence of lateral pruinose patches on the fifth sternite is essentially a characteristic of the species which follow. The structure of the oedeagus might also be considered as intermediate between the two groups.

19. **Phyllophaga speculifera** (Chevrolat).

*Ancylonycha speculifera* Chevr., 1865, Ann. Soc. Ent. France, Ser. 4, Vol. 5, p. 27.

Submedium, narrow, cylindrical; pale brown, elytral punctures, head, pronotum, and median portion of pygidium darker; pronotum and elytra dull, sides of underbody pruinose. Head shining; coarsely, densely, and very irregularly punctured, near each eye a deep narrow impression; clypeus concave, broadly bilobed, median indentation deep, rounded. Pronotum moderately coarsely but rather sparsely punctured, sides subangulately dilated at middle, anterior angles slightly produced, basal angles obtuse but distinct, anterior and lateral margins fine but entire, basal margin replaced by a series of coarse punctures. Scutellum with a few moderately coarse punctures. Elytra moderately and rather more densely punctured than pronotum, without trace of costae, the punctures isolated on dark spots and not tending to run together in lines, epipleura narrow. Apical callus of each elytron with a highly polished and darker, transversely triangular spot. Pygidium shining, coarsely and rather sparsely punctured. Median portions of underbody highly polished and very sparsely punctured, sides of metathorax sparsely and moderately coarsely punctured, posterior coxal plates more coarsely and densely, sides of abdominal sternites more finely and densely, punctured. Legs unusually slender, especially the femora, shining, anterior tibia strongly tridentate, longer of the calcaria of the posterior tibia broad and acuminate, about as long as the first tarsal segment. Claws more finely built than is usual. Length, 12–13 mm.

*Type locality.*—"Cuba."

*Type.*—Cotypes possibly in the collection of J. Moser, Berlin, and in the Poey collection, now at the Academy of Natural Sciences, Philadelphia.

Material examined: The above mentioned specimens in the Poey collection.

The available material consists of two females, resembling in coloration *P. vermiculata* Chpn. but in sculpture, *P. cardini* Chpn. The unusually slender legs of *P. speculifera* Chevr. are so strikingly different from those of *P. cardini* that there seems to be no doubt that the latter is not merely a melanic individual of the former. Chevrolat's statement that the tooth on the

tarsal claw is smaller than usual is true only in the absolute sense; the entire claw is smaller and more delicate.

### 20. **Phyllophaga cardini** n. sp.

Submedium, pruinose, uniformly piceous. Frons coarsely, irregularly, subrugosely punctured, with a median triangular impunctate area adjoining the vertex. Clypeus coarsely, densely, and rugosely punctured, margin broadly and abruptly reflexed, median indentation broad and deep, rounded. Pronotum finely and sparsely punctured, sides subangulate at middle, lateral margins very narrowly reflexed, anterior angles hardly produced, basal angles narrowly rounded, anterior and basal margins complete. Scutellum sparsely punctured. Elytra a little more densely punctured than pronotum, sutural margin not notably tumid, and elevated only near the scutellum, discal costae perceptible, epipleura narrow, their surface with a few short setae. Apical callus of each elytron with a very small shining spot. Pygidium (female) more shining than the upper surface generally, coarsely and sparsely punctured, sparsely hairy, the median line broadly and shallowly impressed. Metathorax shining at middle, pruinose and hairy at sides, first abdominal sternite completely covered at sides by posterior coxal plates, which are rather coarsely and not densely punctured, median portion of sternites (except fifth) shining, lateral portions and almost all of fifth pruinose, sixth shining and coarsely punctured. Upper tooth of anterior tibia strongly developed, longer calcar of posterior tibia (female) of usual shape and twice as long as the first tarsal segment. Claw with strong median tooth, apical portion slender. Length, 12.5 mm.

*Type locality.*—Baracoa, Oriente.

*Type and paratypes.*—U. S. N. M. Cat. No. 43795.

Material examined: One female, the type, collected at the above locality April, 1916, by P. Cardin; two females collected at Jaronu, Camaguey, April 19 to May 6, L. C. Scaramuzza (C. S. C. No. 4027).

### 21. **Phyllophaga analis** (Burmeister).

(Plate III, Fig. 31.)

*Ancylonycha analis* Burm., 1855, Handb. Ent., Vol. 4, Part 2, p. 340; Chevrolat, 1865, Ann. Soc. Ent. France, Ser. 4, Vol. 5, p. 28.

*Ancylonycha bifoveolata* Du Val, 1856, in Sagra, Hist. Cuba, Vol. 7, p. 57; Chevr., 1865, loc. cit., p. 27 [female].

*Ancylonycha subsericans* Du Val, 1856, loc. cit., p. 56; Chevr., 1865, loc. cit., p. 27 [male].

*Male.*—Submedium, pruinose, piceous with abdomen and legs paler. Frons long and rather flat for the genus, moderately coarsely and quite sparsely punctured, clypeofrontal suture biarcuate and very deeply impressed, clypeus narrow, coarsely and sparsely punctured, margin narrowly and abruptly reflexed, carinate just before the indentation, which is sharply angulate. Antennal club shorter than stem. Pro-

notum rather coarsely and sparsely punctured, sides broadly rounded, anterior angles acute and distinctly produced, posterior angles very broadly rounded. Scutellum with very few punctures. Elytra sparsely and more finely punctured than pronotum, sutural margin hardly differentiated from the rest of the elytron, discal costae obliterated, epipleura very narrow. Pygidium convex, moderately coarsely and densely punctured, shining at middle. Metathorax sparsely punctured, shining at middle, pruinose at sides, very sparsely hairy. Abdominal sternites shining at middle, pruinose and finely and moderately densely punctured at sides. Upper tooth of anterior tibia well-developed, longer calcar of posterior tibia hardly longer than the first tarsal segment. Claw with median tooth sharp, its apex directed basally, apical portion slender, strongly curved. Length, 12–15 mm. Oedeagus, Figure 31.

*Female.*—Slightly larger than male, piceous, head, pronotum, and portions of elytra shining, rest of elytra pruinose. Frons almost impunctate, the median line with a deep, oval depression at the bottom of which there are a few large punctures, and on either side of the middle there is a large, circular, shallow depression occupying most of the available space. Clypeus at sides strongly and abruptly elevated above the surface of the frons, with a few coarse punctures near middle, margin narrowly and abruptly reflexed, median indentation sharply angulate. Pronotum and scutellum as in male. Elytra as in male except for two shining areas on each. Basally there is a broad, subtriangular area reaching from the scutellum to beyond the humeral callus and prolonged backward to just before the middle of the length of the elytron. Subapically and near the lateral margin there is a second shining area of irregular shape. The shining portions of the elytra are minutely and very densely punctulate. Under parts much as in the male, the sternites densely punctured at the sides. Legs as in the male, the calcaria of the posterior tibia not as broad as usual in females of this genus. Length, 13–15 mm.

*Type locality.*—"Cuba."

*Type.*—Of *analis*, probably at Halle; of *bifoveolata* and *subsericans*, possibly in collection of J. Moser, Berlin.

Material examined: Four males and four females from Santiago de las Vegas, Havana, June 7, 1927, S. C. Bruner; one female from Hoya Colorado, Havana, June 9, 1924, C. Enamorado; ten males and thirteen females from Cayamas, Santa Clara, May 5–25, E. A. Schwarz; one male and four females from the same place, April 17, 1905, G. Dimmock; two females from Constancia, Santa Clara, May, 1914, J. F. Merrill; one male and two females from Alquizar, Havana, taken at light June 8, 1927, by L. C. Scaramuzza (T. P. R. F. Nos. 3062, 3407); five males and five females from Baragua, Camaguey, taken at light by L. C. Scaramuzza and C. F. Stahl (T. P. R. F. Nos. 3062, 3407); nine males and nineteen females from Santa

Fe, Isle of Pines, August 13, 1918, W. F. Pack; one male from Neuva Gerona, Isle of Pines, July 31, 1912.

The present species is the only one of the Cuban representatives of *Phyllophaga* so definitely sexually dimorphic that the sexes bear little resemblance one to the other. It is also the only species of this genus from the island known to the writer from any part of the American continent. A pair was taken at Ancon, Panama, May 10, 1909, feeding on "mariones."

22. **Phyllophaga imitatrix** n. sp.
(Plate III, Fig. 32.)

Small, dull yellowish- to reddish-brown, head dark castaneous. Frons finely and sparsely punctured, with a small depression at the middle of the clypeofrontal suture which is moderately deeply impressed. Clypeus rather finely and moderately densely punctured near margins, more sparsely so toward frons, margin very narrowly and abruptly reflexed, median indentation shallow but sharply angulate. Pronotum finely and rather sparsely punctured laterally, more densely so on disc, sides evenly rounded, lateral margins very narrowly reflexed basally and apically, almost effaced at middle, anterior angles not produced but sharp, basal angles broadly rounded. Both anterior and basal margins narrowly broken across disc. Scutellum almost impunctate. Elytra opaque, sutural margin tumid and slightly elevated, discal costae faintly indicated, punctures fine and sparse, epipleura very narrow. Pygidium strongly and moderately densely punctured. Metathorax sparsely punctured, shining toward middle, abdominal sternites finely and more densely punctured, especially at sides, than metathorax, median portions shining. Upper tooth of anterior tibia well-developed, longer calcar of posterior tibia longer than the first tarsal segment. Claw with a quite small median tooth which is triangular, the apical portion of claw slender and curved. Length, 11 mm. Oedeagus, Figure 32.

*Type locality.*—Santa Barbara, Isle of Pines.

*Type.*—U. S. N. M. Cat. No. 43796.

Material examined: One male, the type, taken at the above locality March 15, 1923, by S. C. Bruner.

This species is evidently closely related to *P. analis* Burm. In addition to the differentials mentioned in the key, it is separable from that species by its smaller size, slightly more shining integuments, the smaller median tooth of the claw, and the more evenly curved lateral lobe of the oedeagus.

23. **Phyllophaga labrata** n. sp.
(Plate III, Fig. 34.)

Small, shining, head and pronotum with a greenish luster; pale brown, elytra with suture slightly darker, pronotum and head

castaneous. Frons moderately and evenly convex, rather coarsely and not densely punctured, clypeus very narrow, its anterior half rather abruptly reflexed, median indentation very broad and shallow, angulate. Antennal club short and stout. Pronotum more finely punctured than head, sparsely on disc, more densely in anterior angles, which are very narrowly rounded. Sides and posterior angles broadly rounded, lateral margin fine, hardly reflexed. Scutellum rather densely punctured. Elytra closely punctured, sutural margin only slightly tumid and elevated, epipleura very narrow. Pygidium rather densely punctured at sides, sparsely punctured at middle. Metathorax pruinose at sides, shining at middle, sparsely punctured. Abdominal sternites more densely punctured, the first, the sides of the second to fourth, and the lateral thirds of the fifth, pruinose. Upper tooth of the anterior tibia well-developed. (Posterior legs missing from type specimen.) Claw with a small tooth near base, apical portion of claw long and not greatly curved. Length, 10 mm. Oedeagus, Figure 34.

*Type locality.*—Herradura, Pinar del Rio.

*Type.*—U. S. N. M. Cat. No. 43797.

Material examined: A single defective male, the type, taken at Herradura by W. M. Mann.

The peculiar structure of the labrum, as described in the key, sets this species off from all others of the genus known to me.

24. **Phyllophaga suturalis** (Chevrolat).

(Plate III, Fig. 33.)

*Ancylonycha suturalis* Chevr., 1865, Ann. Soc. Ent. France, Ser. 4, Vol. 5, p. 28.

Small, shining with aeneous luster, sides of thorax and fifth abdominal sternite pruinose. Pale yellowish-brown, head, pronotum, and elytral suture piceous. Frons coarsely and sparsely punctured, clypeofrontal suture moderately impressed, clypeus more densely and finely punctured, median indentation broad, shallow but sharply angulate, margins narrowly but abruptly reflexed. Pronotum punctured similarly to frons, sides feebly dilated at middle, lateral margins slightly sinuate in anterior half and finely margined throughout, anterior angles right, basal angles obtuse. Scutellum moderately densely and coarsely punctured except near the middle of the base. Elytra more closely and finely punctured than pronotum, sutural margin hardly elevated, discal costae absent, epipleura very narrow. Pygidium very sparsely and rather coarsely punctured. Metathorax almost impunctate at middle, moderately densely punctured at sides, posterior coxal plates more finely and sparsely punctured. Abdominal sternites sparsely punctured at middle, the sides of the second and third more densely punctured. Anterior tibia slender, the upper tooth feeble. The longer of the calcaria of the posterior tibia longer than the first tarsal segment. Claws moderately long, curved; the tooth, nearer the base than apex, small and directed basally. Length, 10–11 mm. Oedeagus, Figure 33.

*Type locality.*—"Cuba and the Isle of Pines."

*Type.*—Possibly in the collection of J. Moser, Berlin.

Material examined: One male and two females from Cayamas, Santa Clara, May 7–20, E. A. Schwarz; one female from Jatibonico, Santa Clara, April 23, 1931, L. D. Christenson (C. S. C. Ent. No. 5133D).

By his comments, Chevrolat indicated that the specimens before him from the Isle of Pines in reality belong to a different species, possibly the one described below as *P. aeneotincta*.

### 25. **Phyllophaga aeneotincta** n. sp.

(Plate III, Fig. 37.)

Small, integuments above with a slight greenish luster, dark testaceous to light brown, head, disc of pronotum, scutellum, and disc of elytra piceous. Frons coarsely, densely, and evenly punctured, median line just above the clypeofrontal suture impressed, clypeus short, concave, moderately coarsely and rather sparsely punctured, median indentation broad, moderately deep and subangulate, margin abruptly reflexed. Pronotum sparsely set with punctures of about the size of those of the clypeus, sides broadly and roundly dilated at middle, lateral margin very slightly sinuate in anterior half and finely margined throughout its length, anterior margin entire, basal margin wanting and replaced by a series of coarse punctures. Scutellum moderately densely punctured on posterior half. Elytra a little more coarsely and densely punctured than pronotum, sutural margin hardly differentiated from rest of the elytral surface, discal costae obliterated, epipleura very narrow. Pygidium coarsely and rather densely punctured. Metathorax impunctate at middle, rather coarsely and not densely punctured at sides, posterior coxal plates and abdominal sternites more finely and densely punctured, fifth sternite with lateral pruinose patches. Upper tooth of anterior tibia sharp and well-defined, longer calcar of posterior tibia longer than the first tarsal segment. Claw slender, median tooth stouter but not longer than apical portion. Length, 9.5 mm. Oedeagus, Figure 37.

*Type locality.*—Santa Fe, Isle of Pines.

*Type and paratype.*—U. S. N. M. Cat. No. 43798.

Material examined: A pair, of which the male is type, from the above locality, collected August 13, 1918, by W. F. Pack.

This may be the species upon which Chevrolat based his Isle of Pines record for *Ancylonycha suturalis*.

### 26. **Phyllophaga dissimilis** (Chevrolat).

(Plate III, Fig. 35.)

*Ancylonycha dissimilis* Chevr., 1865, Ann. Soc. Ent. France, Ser. 4, Vol. 5, p. 26.

Small, integuments above with a greenish-brassy luster, color uniform piceous. Frons convex, coarsely and moderately densely

punctured, clypeofrontal suture sinuate and well-defined, clypeus shallowly concave, punctured similarly to frons, median indentation shallow, margin narrowly but sharply reflexed. Pronotum more finely but equally as densely punctured as frons, sides broadly rounded, anterior and lateral margins fine and entire, basal margin wanting, replaced by coarse punctures. Anterior and basal angles obtuse. Scutellum evenly and rather densely punctured except at middle of base. Elytra subrugose, with a few isolated setae, sutural and discal costae faintly indicated, punctures more fine and dense than those of pronotum, those on disc tending to be connected by short, transverse grooves, epipleura very narrow. Pygidium rather finely and densely punctured basally, more sparsely so apically. Front face of anterior femora, sides of pro-, meso-, and metathoraces, posterior coxal plates, almost all of first and second sternites, sides of third and fourth sternites, and lateral thirds of fifth sternite, pruinose. Sides of underbody rather finely and not densely punctured. Upper tooth of anterior tibia distinct, calcaria of posterior tibia nearly equal in length, the longer about as long as the first tarsal segment. Claw long and slender, curved, the tooth subbasal, triangular, and directed slightly basad. Length, 10–11.5 mm. Oedeagus, Figure 35.

*Type locality.*—"Cuba."

*Type.*—Cotypes possibly in the collection of J. Moser, Berlin; and the Poey collection at the Academy of Natural Sciences, Philadelphia.

Material examined: Four males and one female (cotypes) in the Poey collection; one male from Perico, Matanzas, April, 1922, B. T. Barreto; twelve males and twelve females from Cayamas, Santa Clara, May 5 to 26, E. A. Schwarz; five males and two females from Constancia, Santa Clara, May, 1914, J. F. Merrill; nine males and seven females from Baragua, Camaguey, April to July, D. L. Van Dine, L. C. Scaramuzza and L. D. Christenson (T. P. R. F. Nos. 1042, 1061, 1071, 1108, 3594, 5343–45); one male and one female from Jaronu, Camaguey, May 11 to June 3, B. T. Barreto and L. C. Scaramuzza (C. S. C. Ent. Nos. 5147, 5148); two males from Jobabo, Oriente, May 11, 1925, C. F. Stahl (T. P. R. F. No. 178).

### 27. **Phyllophaga microsoma** n. sp.

(Plate III, Fig. 36.)

Small, size and general appearance of *P. suturalis* Chevr., but with the sutural stripe slightly wider and the sutural margin more distinctly elevated. Frons somewhat convex, moderately coarsely and sparsely punctured, clypeus lightly concave, more finely and densely punctured, median indentation shallow, margin narrowly but abruptly reflexed. Pronotum rather finely and quite sparsely punctured on disc, more

densely punctured laterally, sides very obtusely subangulately dilated at middle, lateral margins fine, a little wider near anterior angles, anterior margin entire, basal margin wanting. Scutellum sparsely punctured. Elytra rather finely and somewhat more densely punctured than pronotum, sutural margin tumid and slightly elevated, discal costae obliterated, epipleurae very narrow. Pygidium with punctures as coarse and set as sparsely as on elytra. Median portion of underbody almost impunctate, the sides of the metathorax, the posterior coxal plates, and the sides of the abdominal sternites moderately finely and densely punctured. Part of anterior coxae, sides of thorax, posterior coxal plates, most of first, sides (narrowly) of second to fourth, and lateral fourths of fifth sternites, pruinose. Upper tooth of anterior tibia small but distinct, longer calcar of posterior tibia longer than first tarsal segment. Claw as in *P. dissimilis* Chevr. Length, 10.5 mm. Oedeagus, Figure 36.

*Type locality.*—Camaguey, Camaguey.

*Type.*—U. S. N. M. Cat. No. 43799.

Material examined: One male, the type, from Camaguey, taken July 30, 1923, by J. Acuna.

### 28. **Phyllophaga bruneri** n. sp.

(Plate III, Fig. 38.)

Small, shining, almost without metallic luster, brownish-testaceous, head, disc of pronotum, elytral suture, and narrow lateral margins, piceous. Frons moderately coarsely and sparsely punctured, median line slightly impressed, clypeus more finely and sparsely punctured, almost flat, median indentation rather deep and angulate, margin abruptly reflexed. Pronotum sparsely and not coarsely punctured, sides broadly rounded, anterior and lateral margins entire, basal margin replaced by a row of coarse punctures. Scutellum sparsely punctured. Elytra more finely and about as densely punctured as pronotum, sutural margin tumid and slightly elevated, discal costae obliterated, epipleura narrow. Pygidium finely and sparsely punctured. Metathorax laterally rather coarsely and not densely punctured, posterior coxal plates and sides of abdominal sternites more finely and as densely punctured. Metepimera, posterior coxal plates, first, extreme lateral portions of second to fourth, and lateral thirds of fifth, sternites, pruinose. Upper tooth of anterior tibia small but distinct, longer calcar of posterior tibia about twice as long as the first tarsal segment. Claw slender, slightly curved, tooth triangular, median, stouter than apical portion. Length, 9 mm. Oedeagus, Figure 38.

*Type locality.*—Santiago de las Vegas, Havana.

*Type.*—U. S. N. M. Cat. No. 43800.

Material examined: A single male, the type, from the above locality, collected June 14, 1921, by B. T. Barreto.

29. **Phyllophaga alquizara** n. sp.
(Plate III, Fig. 39.)

Small, shining, with a slight greenish luster, brownish-testaceous, head, disc of pronotum, scutellum, and disc and narrow lateral margins of elytra, piceous. Frons coarsely and moderately densely punctured, clypeo-frontal suture sinuate and rather deeply impressed, clypeus more finely and as densely punctured as frons, margin narrowly and abruptly reflexed, median indentations rather deep and subangulate. Pronotum rather finely and sparsely punctured, sides subangulately dilated at middle, anterior and lateral margins entire, basal margin replaced by punctures, anterior angles acute, basal angles obtuse but well-defined. Scutellum sparsely punctured laterally. Elytra more finely and densely punctured than pronotum, sutural margin slightly tumid but hardly elevated, discal costae faintly indicated, epipleura very narrow. Pygidium finely and sparsely punctured. Metathorax rather coarsely and sparsely, the posterior coxal plates more finely and a little more densely, abdominal sternites still more finely and sparsely, punctured. Mesothorax, metepimera, posterior coxal plates, and a small spot on either side of the fifth sternite, pruinose. Upper tooth of anterior tibia well-developed, longer calcar of posterior tibia a little longer than the first tarsal segment. Claw as in *P. bruneri*. Length, 10 mm. Oedeagus, figure 39.

*Type locality.*—Alquizar, Havana.

*Type.*—U. S. N. M. Cat. No. 43801.

Material examined: One male, the type, from Alquizar, taken at light June 8, 1927, by L. C. Scaramuzza (T. P. R. F. No. 1108).

30. **Phyllophaga aeruginosa** (Burmeister).
(Plate III, Fig. 40.)

*Ancylonycha aeruginosa* Burm., 1855, Handb. Ent., Vol. 4, Part 2, p. 338; Chevrolat, 1865, Ann. Soc. Ent. France, Ser. 4, Vol. 5, p. 26.

Small, shining, integuments above with a faint greenish luster, rufotestaceous, head, pronotum (except flanks), scutellum, and disc and lateral margins of elytra, piceous. Frons coarsely and sparsely punctured, median line distinctly impressed, clypeofrontal suture well-defined, clypeus short, concave, rather finely and sparsely punctured, margin gradually reflexed, median indentation moderately deep and angulate. Pronotum coarsely and sparsely punctured, with a small longitudinal impunctate area lying in the median line on the posterior half, sides broadly, subangulately dilated at middle, anterior and lateral margins entire, anterior angles slightly produced, basal angles broadly rounded, basal margin replaced by coarse punctures. Scutellum coarsely punctured laterally. Elytra more finely and densely punctured than pronotum, sutural margin slightly tumid but hardly elevated, discal costae faintly indicated, epipleura moderately wide. Pygidium coarsely and sparsely punctured. Metathorax coarsely and sparsely, posterior coxal plates and abdominal sternites more finely and a little

more densely, punctured; sides of thorax, posterior coxal plates, and lateral thirds of fifth abdominal sternite, pruinose. Upper tooth of anterior tibia strong, about half as long as middle tooth, longer calcar of posterior tibia more than half as long as the first tarsal segment. Claw slender, tooth proportionately large and situated a bit beyond the middle. Length, 10–12.5 mm. Oedeagus, Figure 40.

*Type locality.*—"Cuba."

*Type.*—Probably at Halle.

Material examined: Three females from Santiago de las Vegas, Havana, May 27 to August 10, collected by S. C. Bruner and B. T. Barreto; eight males and six females from Cayamas, Santa Clara, May 7 to June 11, E. A. Schwarz.

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In addition to the above described species, there are two species previously described that the writer has not been able to identify in the material before him. The original descriptions are quoted below.

**Phyllophaga angusta** (Blanchard).

*Ancylonycha angusta* Bl., 1850, Cat. Coll. Ent. Paris, Coleopt., Vol. 1, p. 138.

"1609. Angusta. Parallela, elongata, fusca, supra picea, nitida, glaberrima; capite parce punctato, clypeo paulo producto, anguloso, emarginato; antennis, palpis pedibusque rufescentibus; prothorace lato, brevi, sat convexo, laxe punctato, lateribus haud crenulato, angulis anticis acutis; scutello punctato; elytris elongatis, parallelis, thoracis latitudine, piceis, nitidissimis, punctis profundis, passim confluentibus; pectore haud villoso, cum abdomine vix sericeo, pruinoso; pygidio nitido, piceo, crebre punctato. Long. 12–13 mm. Donne par M. Ramon de la Sagra. Cuba."

Were it not for the fact that Chevrolat states that he has examined the type of this species, the writer would be inclined to suppress the Chevrolat name *dissimilis* in favor of *angusta* Blanchard. The two are surely closely related.

**Phyllophaga parallela** (Blanchard).

*Ancylonycha parallela* Bl., 1850, Cat. Coll. Ent. Paris, Coleopt., Vol. 1, p. 137.

"1062. Parallela. Oblonga, sat crassa, statura minor praecedentium, omnino testacea, parce sericea; capite fusco, crebre punctato, clypeo testaceo-rufo, laxe punctato, reflexo, paulo emarginato; antennis, palpis pedibusque testaceis; prothorace convexo, lateribus subcrenulato, supra crebe punctato, sericeo, punctis latis, profundis; scutello parce punctato; elytris parallelis, thoracis latitudine, punctato-rugosis, sericeis, lineis elevatis nullis; pectore villoso; abdomine vix sericeo, pygidio parce punctato. Long. 15–16 mm. Donne par M. Ramon de la Sagra. Cuba."

The size and villous metathorax place the species in the first group. Outside of the very large species, there is but one known to the writer which has the margins of the pronotum subcrenulate, viz., *puberula* Du Val. It is possible that the two are synonymous but unless Blanchard had "hairy" in mind when he wrote "sericeous" the two are distinct.

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## EXPLANATION OF PLATES.

### PLATE I.

(Mag. ca 40 ×, except as noted.)

Fig. 1. *Anoplosiagum simplicipes* n. sp. Apical portion of oedeagus.
Fig. 2. *Anoplosiagum peltatum* n. sp. Outline of body. (ca 3.6 ×.)
Fig. 3. *Anoplosiagum rutilus* (Chevr.). Outline of body. (ca 3.6 ×.)
Fig. 4. *Anoplosiagum scabrosum* n. sp. Apical portion of oedeagus.
Fig. 5. *Anoplosiagum peltatum* n. sp. Apical portion of oedeagus.
Fig. 6. *Anoplosiagum rufum* n. sp. Apical portion of oedeagus.
Fig. 7. *Anopolsiagum pallidulum* Blanch. Apical portion of oedeagus.
Fig. 8. *Anoplosiagum rutilus* (Chevr.). Apical portion of oedeagus.
Fig. 9. *Anoplosiagum simplicipes* n. sp. Tarsal claw.
Fig. 10. *Anoplosiagum scabrosum* n. sp. Tarsal claw.
Fig. 11. *Anoplosiagum peltatum* n. sp. Tarsal claw.
Fig. 12. *Anoplosiagum rufum* n. sp. Tarsal claw.
Fig. 13. *Anoplosiagum pallidulum* Blanch. Tarsal claw.
Fig. 14. *Anoplosiagum rutilus* (Chevr.). Tarsal claw.

### PLATE II.

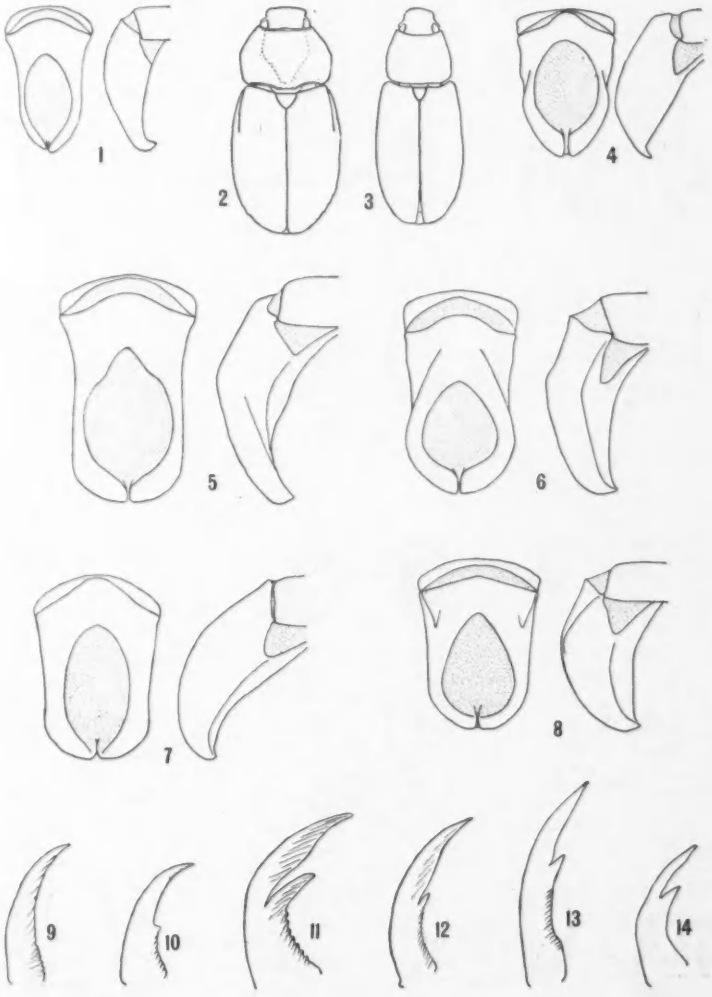
(Mag. ca 5 ×.)

Fig. 15. *Phyllophaga fimbriata* n. sp. Oedeagus.
Fig. 16. *Phyllophaga expansa* n. sp. Oedeagus.
Fig. 17. *Phyllophaga crenaticollis* (Blanch). Oedeagus.
Fig. 18. *Phyllophaga onchophora* n. sp. Oedeagus.
Fig. 19. *Phyllophaga schwarzi* n. sp. Oedeagus.
Fig. 20. *Phyllophaga baraguensis* n. sp. Oedeagus.
Fig. 21. *Phyllophaga puberula* (Du Val). Oedeagus.
Fig. 22. *Phyllophaga baracoana* n. sp. Oedeagus.
Fig. 23. *Phyllophaga signaticollis* (Burm). Oedeagus.
Fig. 24. *Phyllophaga santaclarae* n. sp. Oedeagus.
Fig. 25. *Phyllophaga tetracera* n. sp. Oedeagus.
Fig. 26. *Phyllophaga patruelis* (Chevr). Oedeagus.
Fig. 27. *Phyllophaga cubana* n. sp. Oedeagus.
Fig. 28. *Phyllophaga jaronua* n. sp. Oedeagus.
Fig. 29. *Phyllophaga tenuicalcaris* n. sp. Oedeagus.
Fig. 30. *Phyllophaga vermiculata* n. sp. Oedeagus.

### PLATE III.

(Mag. ca 11 ×.)

Fig. 31. *Phyllophaga analis* (Burm). Oedeagus.
Fig. 32. *Phyllophaga imitatrix* n. sp. Oedeagus.
Fig. 33. *Phyllophaga suturalis* (Chevr). Oedeagus.
Fig. 34. *Phyllophaga labrata* n. sp. Oedeagus.
Fig. 35. *Phyllophaga dissimilis* (Chevr). Oedeagus.
Fig. 36. *Phyllophaga microsoma* n. sp. Oedeagus.
Fig. 37. *Phyllophaga aeneotincta* n. sp. Oedeagus.
Fig. 38. *Phyllophaga bruneri* n. sp. Oedeagus.
Fig. 39. *Phyllophaga alquizara* n. sp. Oedeagus.
Fig. 40. *Phyllophaga aeruginosa* (Burm). Oedeagus.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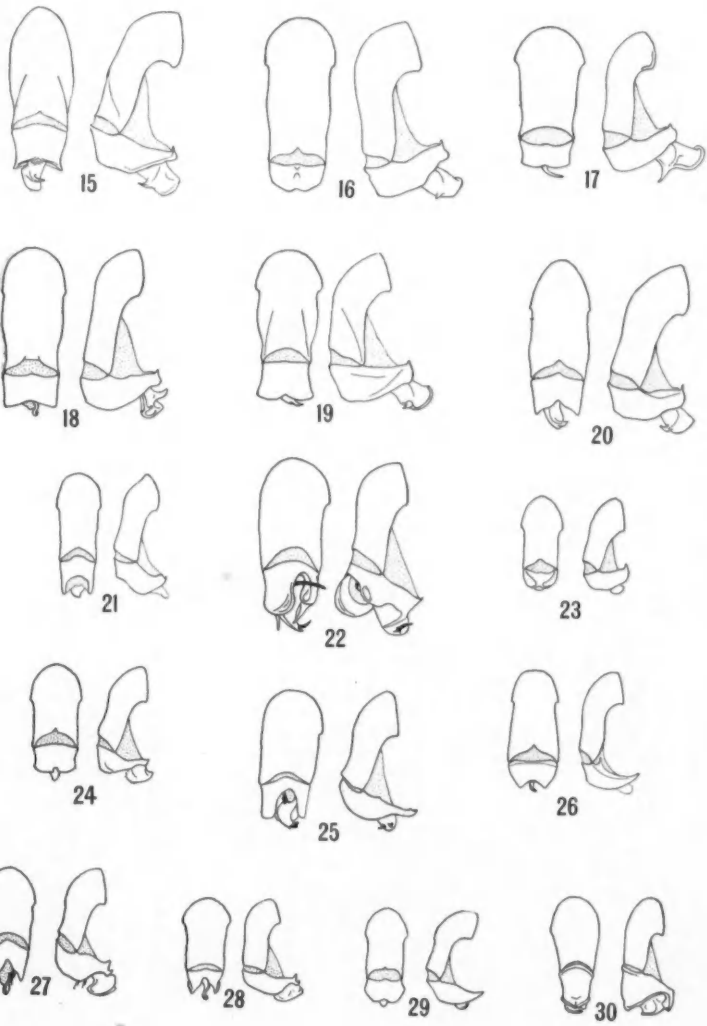
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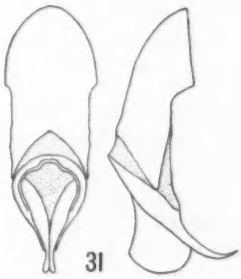
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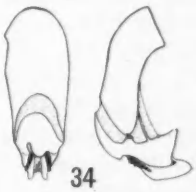
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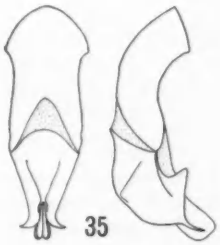
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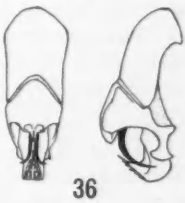
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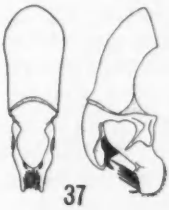
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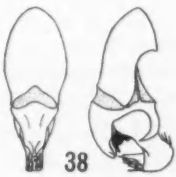
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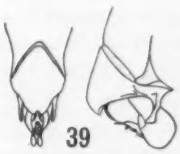
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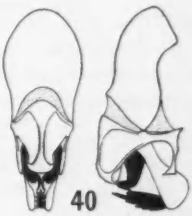
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# THE ALIMENTARY CANAL OF THE APPLE MAGGOT.
## Rhagoletis pomonella Walsh (Dipt.: Trypetidae).

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Ohio State University, Columbus, Ohio.

The anatomy of dipterous larvae has claimed the attention of many investigators in the past but, for the most part, their work has been confined to the scatophagous forms or those of medical importance. In view of their different food habits, and the possible structural modifications which this suggests, and because the group includes several important agricultural pests, a study of the digestive tract of a strictly phytophagous maggot seems warranted. The larva of *Rhagoletis pomonella* was chosen as a typical example of a plant-feeding maggot as the entire feeding period is spent within the fruit of the apple. It is also an important economic pest and an abundance of material was available for study.

The writer wishes to express his indebtedness to Dr. C. H. Kennedy, of the Department of Zoology and Entomology, Ohio State University, for his advice and criticism on the preparation of this paper.

The material was collected during August, 1930, in a heavily infested orchard in northeastern Ohio where the insect has been causing considerable damage to apples for the past several seasons. At the time the collection was made larvae in the earlier varieties of fruit were nearly full grown, all of the individuals taken being in the third instar. These were dropped directly into Kahle's Fixative upon being removed from the fruit where they were still feeding. Although the body cavity was not opened for the penetration of the fixative, most of the material was found to be well preserved several months later.

Usually the whole digestive tract was prepared and sectioned in one series, either removed from the body or in place. Sections were stained in various combinations of Delafields Haematoxylin, Haemalum, Eosin, Light Green and Fast Green. Very good results were obtained by triple staining in Delafields Haematoxylin, Eosin and Fast Green. Primary cuticula and the peritrophic membrane were stained red or pink by the Eosin, secondary cuticula and cytoplasm stained green, and the nuclei were dark purple.

## GENERAL DESCRIPTION.

The larva is of the usual form found in the higher Diptera. It is white or cream-colored, more or less cylindrical, footless, consisting of eleven true segments and a conical headpiece. As seen from above, the body tapers from the sixth segment towards the anterior end, becoming about one-third as wide at that end as in the middle. The seventh, eighth and ninth segments are of approximately the same width, the tenth and eleventh segments tapering slightly towards the posterior end. A full grown maggot is from 7 to 8 mm. long and 1.7 to 2 mm. wide at the widest portion.

The mouth opening is located between the two oral hooks which are borne on the larval headpiece. The first true segment bears a pair of yellowish, fringed, lobe-like organs, the anterior larval spiracles. The last segment of the body bears two plate-like posterior spiracles on its obliquely flattened caudal surface, and the anus, which opens on its ventral surface between two well-developed lobes.

## GROSS ANATONY OF THE ALIMENTARY CANAL.

(Plate I, Fig. 1; Plate II, Fig. 2.)

The alimentary canal of the apple maggot is a continuous tube beginning with the oral cavity at the anterior end of the body and terminating at the anus in the posterior end. It is divided into three main parts, the fore-, mid- and hind-intestines and their appendages. In the full grown larva the fat body forms a sheath around almost the whole digestive tract and, together with numerous tracheae, serves to hold it in place. The positions of the various organs in relation to the segments of the body vary with the degree of contraction of the segments. The description following is that of a larva in which the segments are partially contracted.

The anterior end of the alimentary canal is formed by the pharynx, which is located in the headpiece and first true segment, between the parts of the cephalopharyngeal skeleton. It is equipped with dilator muscles and serves to conduct food from the mouth to the oesophagus. A very complete description and discussion of the pharynx of the larva of *Rhagoletis pomonella* is given by Snodgrass (11). Arising from the posterior end of the oval pharynx is a slender tube, the oesophagus. This extends caudad to the fourth segment where it joins the proventriculus and is invaginated within it to form the oesophageal valve. The mid-intestine, composing the greater part of the alimentary canal, begins at this point. The length of the oesophagus in a larva 7 mm. long is about 1 mm. On either side of the oesophagus and close to the ventral wall of the body are a pair of tubular salivary glands. These extend from the second into the sixth segment and are connected at their anterior ends by a slender, forked duct which opens into the pharynx through its ventral wall near the mouth. The above structures comprise the fore-intestine and its appendages. They are ectodermal in origin.

The mid-intestine is in the form of a convoluted tube approximately 21 mm. long and varying in diameter from 0.5 to 0.01 mm. in the full

grown larva. At its anterior end is a globular structure, the proventriculus. Immediately behind this four short, tubular gastric coeca are attached at equal intervals about the circumference of the tube.

The anterior portion of the mid-intestine is somewhat enlarged and has been variously described as the chyle stomach, chylific ventricle, ventriculus, true stomach, etc., the first of these terms being the most commonly used. The chyle stomach extends caudad close to the ventral body wall as far as the eighth segment and then bends abruptly back and to the left for a short distance. It then forms a wide loop to the right and passes above the first straight portion posterior to the proventriculus, becoming somewhat narrower. Then, extending caudad and to the right of the median plane as far as the first bend, over which it forms a short loop to the left, it bends toward the ventral body wall. At this point there is a more or less distinct contraction, the tube enlarging again immediately. The tube then proceeds cephalad, shortly looping to the left and contracting in diameter for a short distance. After forming a loop to the right and upward, the tube extends caudad, loops to the right again, proceeding cephalad a short distance before bending abruptly back on itself and to the left. It next turns toward the ventral surface within the next to the last loop and proceeds cephalad to the middle of the body where it joins the hind-intestine. The mid-intestine is of endodermal origin.

At the junction of the mid-intestine with the hind-intestine arise the two Malpighian tubules, one dorsally and one ventrally attached to the alimentary canal. The bases of the tubules are enlarged and lobe-like, being closely appressed to the enlarged anterior end of the hind-intestine. Each tubule forks a short distance from its base. The length of the branches is not accurately known, but they appear to be about 10 or 15 mm. in length. In older larvae the distal ends of the tubules are greatly enlarged and filled with roughly discoidal concretions, probably *calcospherites* as reported by Keilin (7). In preserved material the enlarged portions are cream-colored in contrast to the decided yellow of the rest of the tubule. See Plate III, Fig. 10. The tubules are slender, moniliform structures of ectodermal origin, being classed as appendages of the hind-intestine.

The anterior end of the hind-intestine is enlarged, being about three times the diameter of the rest of this portion of the alimentary canal. Lowne (8) has termed this the *sinus* in blowfly larvae, and it will be referred to as such in this paper. It composes about one-sixth of the length of the hind-gut. The remainder of the intestine is a simple tube, approximately 4 mm. long and somewhat smaller in diameter than the midgut, but larger than the oesophagus. From its junction with the midgut it extends cephalad from little more than the length of the sinus and then bends abruptly backward, curving directly to the anus in the ventral body wall of the last segment, lying above the loops of the midgut and near the center line of the body. The posterior end is in the form of a very short rectum, its outward appearance being similar to that of the rest of the hind-intestine except that it is slightly larger in diameter. The hind-intestine and its appendages are of ectodermal origin.

## THE HISTOLOGICAL STRUCTURE OF THE ALIMENTARY CANAL.

Those parts of the alimentary canal which are of ectodermal origin, the fore- and hind-intestines, are roughly similar in their histological structure, both being invaginations of the body wall. They are composed of the following layers:

Externally, a layer of circular muscle fibers. In most insects this is followed by a layer of longitudinal muscle, but this is absent in the larva of *Rhagoletis pomonella*, so that the next layer is a thin, non-cellular basement membrane lying against the bases of the epithelial cells which compose the third layer. The cuticula of the body wall is continuous with a chitinous intima lying against the epithelium and forming a fourth layer.

The mid-intestine, being endodermal in origin, differs from the above. The longitudinal muscle layer, which is present in this part of the alimentary canal, overlies that of circular muscles and there is no chitinous intima secreted by the epithelial cells. The basement membrane and epithelial layer are present.

Further differences in the histological structure of the three divisions of the digestive tract are discussed in detail below.

### A. The Fore-intestine and Salivary Glands.

The description of the larval pharynx of *Rhagoletis pomonella* given by Snodgrass (11) is so complete that a further discussion has been omitted from this paper. The walls are composed of a heavy layer of muscle. The epithelium is not discernible, but the chitinous intima is well developed, forming a series of grooves on the floor of the pharynx.

The circular muscle layer composing the outer surface of the oesophagus is of considerable thickness. Following this is the very thin, non-cellular basement membrane connecting the bases of the epithelial cells. The epithelial layer is much reduced, appearing in cross-section as scattered nuclei in a thin band of cytoplasm. When heavily stained, these nuclei may appear as stout spines projecting into the lumen of the oesophagus, as the chitinous lining of the foregut does not stain readily and in many preparations remains nearly transparent. This intima is very thick and gives the inner face of the oesophagus a rough, irregular surface.

The anterior end of the oesophagus is dorso-ventrally flattened (Plate II, Figs. 5 and 6). Near the junction with the pharynx the muscle layer does not show cross-striations, but these are more or less distinct in the rest of the oesophagus. No traces of longitudinal muscle were found and no peritoneal membrane could be demonstrated. See Plate II, Figs. 5, 6 and 7.

Two layers of tissue comprise the salivary glands, an outer basement membrane, or *tunica propria*, which is non-cellular in structure and very thin, and a layer of large secreting epithelial cells. These are regular in shape and more or less rectangular in cross-section. The cytoplasm is homogeneous in appearance and the nuclei are very large and conspicuous. The whole structure stains heavily in nuclear stains,

such as Delafield's Haematoxylin. Secretion is apparently merocrine, many of the sections prepared showing droplets of secretion at the tips of the cells and scattered through the lumen of the gland. See Plate IV, Fig. 19.

At the junction of the duct with the gland is a region of replacement cells, very distinctly differentiated from the epithelial gland tissue which follows it. The cells are small, very irregular in shape, the nuclei are small and the cytoplasm is somewhat granular in appearance. The duct, itself, is composed of a sheath of flat cells over a non-cellular intima. This last exhibits a spiral thickening very similar to the taenidia in a trachea. Such a structure is known to occur in many species and is considered as evidence that salivary glands in insects may have developed from the "lost" prothoracic spiracles. No trace of a chitinous intima was found in the gland proper. See Plate III, Fig. 9.

### B. The Oesophageal Valve and Proventriculus.

The oesophageal valve is composed partly of fore- and partly of mid-intestinal tissue. It is a very distinctly valvular structure formed by an invagination of the oesophagus into the proventriculus. In longitudinal section the lips of the valve show all the tissue layers of the oesophagus, first in reverse order and then in their proper sequence, indicating that the oesophagus first extends well into the proventriculus and then turns back over itself, extending cephalad until it joins a ring of tissue composed of large clear cells which form a core in the proventriculus. These are modified endodermal cells whose exact function is not known. A ring of similar tissue is found in the pyloric region and will be described later in connection with that part. Anterior to this and continuous with it is a ring of embryonic cells which give rise to the oesophageal valve in the imago. These tissues lie close to the invaginated oesophagus and usually free of the walls of the proventriculus, with which the embryonic tissue is continuous.

Only two tissues can be distinguished in the proventricular wall. These are a thin basement membrane and a wall of heavy, regularly-shaped cells which stain darkly and evenly in the nuclear stain, so that the cell walls are not easily distinguished. The nuclei are large and distinct. These cells are very different in appearance from the epithelial cells of the mid-intestine, with which they are continuous.

All food in the midgut is enclosed in a thin tube of non-cellular material, the peritrophic membrane, which is chitinous in nature. Folsom and Welles (3) have described the formation of this membrane in Collembola from a non-chitinous, striated intima lining the mid-intestine of that insect. A similar intima occurs in the mid-intestine of the larva of *Rhagoletis pomonella*, but no indications of the formation of the perithropic membrane from it were seen. On the other hand, a number of sections were obtained which showed the peritrophic membrane apparently originating from the cells comprising the wall of the proventriculus and extending from there down into the lumen of the mid-intestine. This is in accord with the recent findings of Wigglesworth (12) in regard to other species of dipterous larvae.

The structure of the oesophageal valve and the proventriculus is shown in Plate II, Fig. 3.

### C. The Mid-Intestine and Gastric Coeca.

Scattered strands of longitudinal muscle are found in the walls of the mid-intestine, but do not occur in either the fore- or hind-intestines, with one exception, which will be mentioned later. They form the outermost tissue layer. In cross-section they are small and inconspicuous. Circular muscle fibers occur just beneath these and are also widely separated and inconspicuous, being much less apparent than the corresponding tissues in the fore- and hind-guts. The circular muscles extend completely around the intestine and, together with the longitudinal muscle fibers, form a sort of network or lattice over its outer surface. Parts of this network, torn loose from the intestine, were visible in some of the preparations so that its form and character were easily seen. Under the higher powers of the binocular microscope the circular muscles were visible in most dissections, but the less conspicuous longitudinal muscles could not be seen.

The epithelial layer, on the other hand, is very conspicuous and is composed of large, irregularly-shaped cells. These were easily visible through the overlying tissues and could be seen with the medium power objectives of the binocular. Usually these cells are more or less flattened, but in that portion of the midgut immediately posterior to the proventriculus, they are somewhat elongated. The nuclei are large and very conspicuous. The inner margins of the cells are covered with a heavy, striated border, such as has been described by Folsom and Welles in the midgut of Collembola. The elongated cells in the anterior end of the chyle stomach and the cells in the bases of the gastric coeca do not show this striated margin as distinctly as the cells further back. A very thin basement membrane lies between the muscle network and the epithelial layer, connecting the bases of the cells of the latter. A peritoneal membrane, if present, could not be demonstrated.

Several modifications of the epithelium in the mid-intestine were observed. The elongation of the cells in the chyle stomach has been mentioned, as has the indefinite character of the striated margin in that region. The typical epithelial cells posterior to the chyle stomach are flattened and show a heavy striated margin.

Following this and in the approximate middle of the midgut is a region in which the epithelial cells do not show any traces of a striated margin and in which the cytoplasm is more homogeneous in appearance and of finer texture than elsewhere. These cells are, at first, of medium size, the intestine being constricted. They gradually become broader and some of them appear to flatten out, the nuclei disappearing or becoming very inconspicuous and the cytoplasm assuming a fibrous appearance. The intestine may again constrict and, following this, the epithelial layer assumes its typical appearance. The appearance of this region in cross-section is shown in Plate III, Fig. 14. Often the epithelium in a large part of the mid-intestine is greatly reduced, the intestinal wall becoming very thin. See Plate III, Fig. 8. The appearance of the chyle stomach in cross-section is shown in Plate II, Fig. 4.

The appearance of the cytoplasm is variable. In some preparations it is more or less even, being slightly granular, while in others the cell appears entirely filled with droplets of a clear, colorless substance which takes no stain, so that the cytoplasm has the appearance of a network. This particularly is true of the sections from the posterior end of the mid-intestine.

No cell-nests, or *nidi*, occur in any part of the mid-intestine. According to Newcomer (9), insects which feed continuously (as does the apple maggot) secrete digestive fluids continuously. The epithelial cells are not destroyed in the process, which is merocrine. Therefore, no nidi are necessary to supply new cells, replacement occurring only at the time of moulting. Most of the continuous feeders are phytophagous. Sections through the chyle stomach often show a lightly stained area between the epithelial cells and the peritrophic membrane. This is probably a digestive secretion of the cells. It does not occur in the form of droplets as in the salivary glands, but is continuous. The phenomenon was observed only in the region of the chyle stomach. It is possible that digestion takes place at this point, absorption occurring in the rest of the midgut. A fact of some physiological significance is the change which takes place in the sugars in the apple during the ripening process. According to Browne (1), there is a marked increase in the total sugars, especially of invert sugars, in over-ripe fruit. Such foods would require little digestion before their assimilation by the cells of the organism. It is especially significant that the apple maggot does not, and apparently cannot, complete its development until the fruit reaches the over-ripe stage.

The four gastric coeca are short, tubular diverticula similar in their histological structure to the mid-intestine just posterior to the proventriculus. The muscle layers, if present, are much reduced. Their existence is doubtful. The coeca open freely into the mid-intestine and are attached, two on each side, immediately behind the proventriculus. Their distal ends are closed. Haseman (4) found that the coecal gland in Psychoda larvae secreted a digestive fluid differing from that of the chyle stomach. Whether this is also true in *Rhagoletis pomonella* is not known.

### D. The Pyloric Region and the Malpighian Tubules.

In many species of insects a valve occurs at the junction of the mid- and hind-intestines. Such a structure is absent in the apple maggot. A ring of modified endodermal tissue, similar to that found in the proventriculus, occurs in this region, but it is not a valvular structure. It appears as two thick pads of lightly staining tissue composing the lateral walls of the digestive tract, extending into the enlarged bases of the Malpighian tubules and becoming reduced to thin strands where they extend below the orifices of the tubules. The modified endodermal cells are joined at their bases by a thin basement membrane over which strands of circular muscle are found. No longitudinal muscles were seen, although it would seem probable that they should occur here as they are found in the mid-intestine, anteriorly, and in the sinus,

posteriorly. A diagrammatic view of the pyloric region showing part of the ring of endodermal tissue is shown in Plate IV, Fig. 20 and a number of cross-sections are shown in Plate IV, Figs. 15 to 18.

The Malpighian tubules originate at the anterior end of the sinus. (In the normal position of the organs in the body they are posteriorly located.) Their bases are enlarged and thin-walled, being composed of a single layer of flat cells, a basement membrane and scattered strands of circular muscle. Snodgrass (11) terms them *ampullae*. Each tubule forks once, the branches being thick-walled and having somewhat the appearance of strings of irregular beads. Their walls are composed of an external membrane, lightly staining and rather indefinite, and a single layer of large cells. Many cross-sections of the tubules show only a single cell. This is probably due to the indistinct character of the cell walls and the fact that the large nuclei are rarely opposite each other and so do not appear in the same section. It seems apparent that three cells rarely, if ever, are to be found in a cross-section of the tubule, although two cells have been distinguished. The enlarged terminal portions of the Malpighian tubules have been mentioned previously in the discussion of the gross structures of the digestive tract. The walls of these parts of the tubules are thin and do not show the presence of the basement membrane. See Plate III, Figs. 10 and 11.

Immediately posterior to the junction of the Malpighian tubules is the enlarged end of the hind-intestine, which has been referred to previously as the sinus. It is composed of a single layer of large, regular, somewhat flattened epithelial cells whose bases are covered by a thin membrane. No chitinous intima lines it, as would be expected in a structure of ectodermal origin, and both longitudinal and circular muscles are found, the former lying above the latter as in the midgut. Although all parts of the digestive tract posterior to the junction of, and including, the Malpighian tubules are considered as being hind-intestine, the sinus shows many characteristics of mid-intestinal structure. The striated border of the epithelial cells is lacking, however, the cytoplasm stains lighter and more evenly than in the mid-intestine and the nuclei are smaller and found close to the outer cell-walls. The muscle layers appear as in the midgut.

### E. The Hind-intestine.

Lowne, in his work on the blowfly larva, has divided the hind-intestine into two regions, the *metenteron*, extending from the midgut to the rectum, and the *proctodaeum*, or rectum, considering the latter as being the only part originating from the invagination of the ectoderm. In *Rhagoletis pomonella*, both parts show heavy external layers of circular muscle followed by a thin basement membrane and an epithelial layer which, though much reduced as compared with that of the mid-intestine, is more conspicuous than that of the oesophagus. The cells composing the walls of the sinus are continuous with this epithelium, the transition being rather abrupt and marked by the deeper staining, greater irregularity and smaller size of the cells of the hindgut.

The epithelial cells of the fore part of the hind-intestine are larger than those of the rectum and show an indefinite, non-striated margin,

(Plate III, Fig. 12). There is no chitinous lining, but all food is contained in a peritrophic membrane as in the midgut.

The rectum is short and somewhat thicker than the rest of the hindintestine. The development of the circular muscle layer is greater and the cross-striations in this layer more marked. The epithelial cells are smaller and more irregular in shape. A thin, regular intima of chitin lines the rectum. See Plate III, Fig. 13.

## COMPARISON WITH SCATOPHAGOUS SPECIES.

In general, the digestive tract of the larva of *Rhagoletis pomonella* is very similar to that of scatophagous species as represented by the blowfly, *Calliphora erythrocephala*, and the housefly, *Musca domestica*. The crop which is present in *Calliphora* is absent in both *Musca* and *Rhagoletis*. The gastric coeca appear to be longer in the scatophagous maggots. The length of the alimentary canal is proportionately as great or greater in the apple maggot.

The type of secretion by the epithelial cells of the midgut is probably different from that of the scatophagous species, as the presence of nidi is reported in both, Lowne (8) and Hewitt (5). Hewitt's figure of the digestive epithelium in *Musca* larvae is very similar to that of the *Rhagoletis* larva, but that of Lowne for the larva of *Calliphora* clearly indicates a structure for holocrine secretion. Neither of the scatophagous species are reported to have the modified epithelium found in the apple maggot and shown in Plate III, Fig. 14.

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## EXPLANATION OF PLATES.

### Plate I.

Fig. 1. Gross dissection, organs *in situ*, × 20.

### Plate II.

Fig. 2. Diagrammatic view of the digestive tube removed from the body, × 10.
Fig. 3. Longitudinal section through the oesophageal valve, × 140.
Fig. 4. Cross-section through chyle stomach, × 260.
Figs. 5, 6 and 7. Cross-sections through the oesophagus from pharynx to proventriculus, × 260.

### Plate III.

Fig. 8. Cross-section through the midgut, showing greatly reduced epithelium, × 260.
Fig. 9. Longitudinal section through the anterior end of a salivary gland, × 260.
Fig. 10. Cross-section through the enlarged end of a Malpighian tubule, showing concretions of calcium carbonate, × 260.
Fig. 11. Cross-section through a normal Malpighian tubule, × 260.
Fig. 12. Cross-section through the hind-intestine, × 260.
Fig. 13. Cross-section through the rectum, × 260.
Fig. 14. Cross-section through the midgut, showing modified epithelium, × 260.

### Plate IV.

Fig. 15. Cross-section through junction of Malpighian tubule and intestine, × 260.
Fig. 16. As above, showing opening between ampulla and sinus, × 260.
Fig. 17. As above, showing wide opening between ampulla and sinus, × 260.
Fig. 18. As above, section cut above sinus, × 260.
Fig. 19. Three secreting cells from a salivary gland, × 260.
Fig. 20. Diagrammatic view of the pyloric region, cut open to show the modified endodermal tissue in place, × 66.6.

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## SYMBOLS USED IN PLATES.

Amp.—Ampulla, enlarged base of Malpighian tubule.
B. Mem.—Basement membrane.
C. Mus.—Circular Muscle.
Conc.—Concretion.
Emb.—Embryonic cells.
End.—Modified endodermal tissue.
Epith.—Epithelium.
G. Coe.—Gastric coecum.
H. Int.—Hind-intestine.
Int.—Chitinous intima.
L. Mus.—Longitudinal muscle.
M. Int.—Mid-intestine.
M. Tub.—Malpighian tubule.
Oes.—Oesophagus.
Ph.—Pharynx.
P. Mem.—Peritrophic membrane.
P. Vent.—Proventriculus.
Rec.—Rectum.
R. Tis.—Replacement tissue.
S. Gl.—Salivary Gland.
Sin.—Sinus.
St. Mar.—Striated margin of epithelia cell.

Alimentary Canal of Rhagoletis
R. W. Dean

PLATE I.

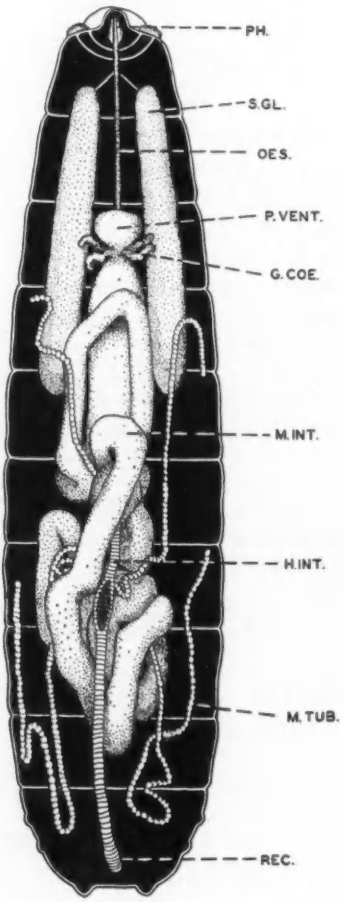


FIG. I

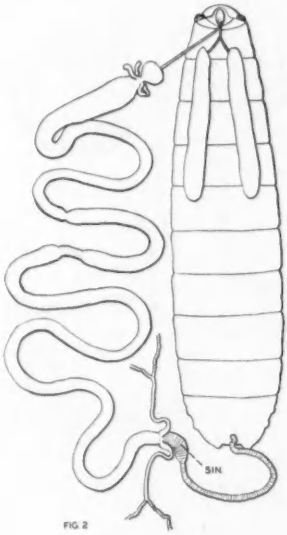


FIG. 2

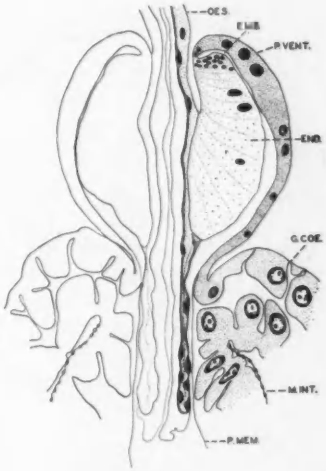


FIG. 3

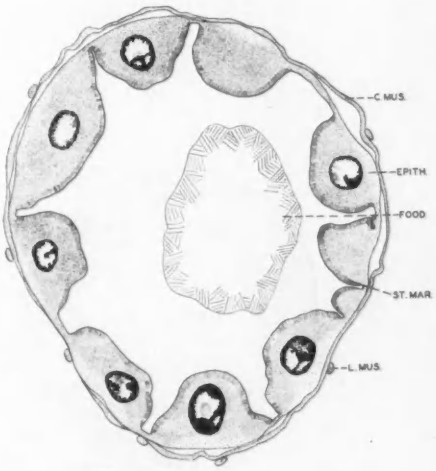


FIG. 4

FIG. 5

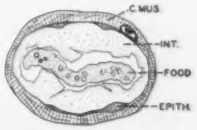


FIG. 6

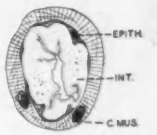


FIG. 7

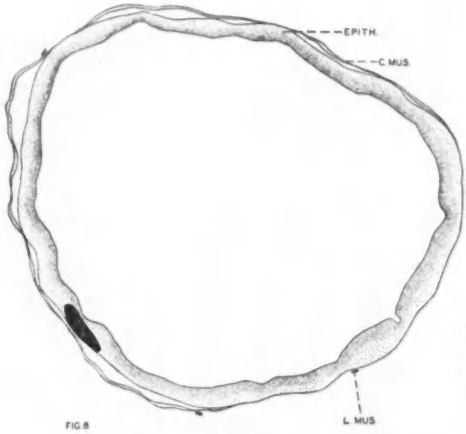


FIG. 8

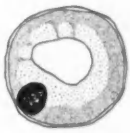

FIG. 11

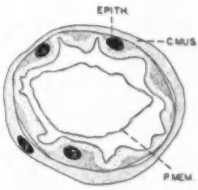


FIG. 12

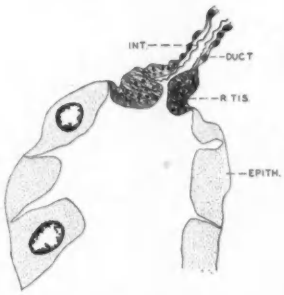


FIG. 9

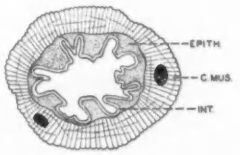


FIG. 13

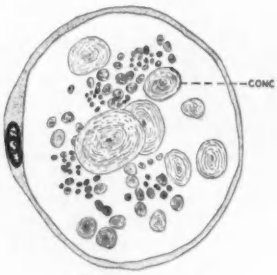


FIG. 10

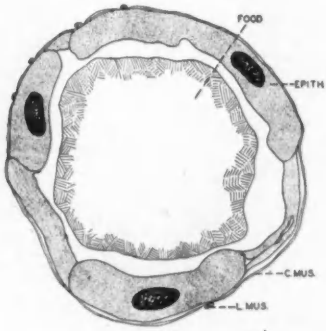


FIG. 14

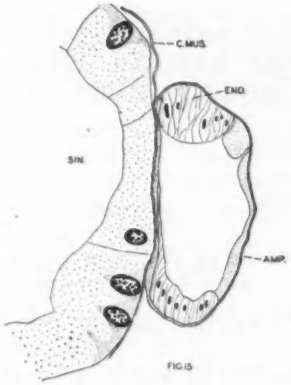


FIG. 15

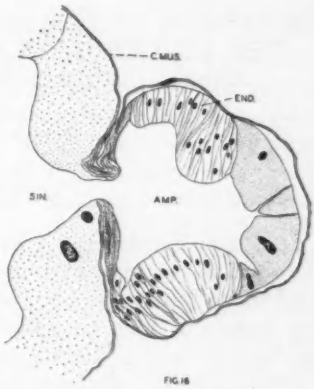


FIG. 16

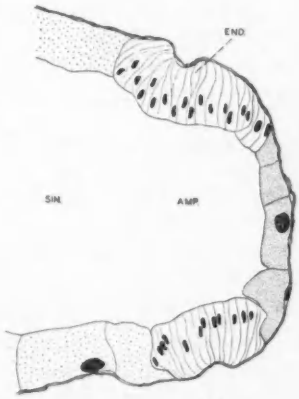


FIG. 17

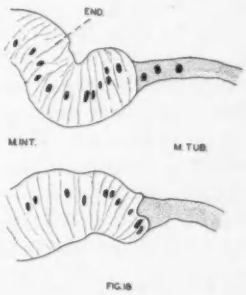


FIG. 18

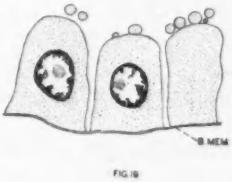


FIG. 19

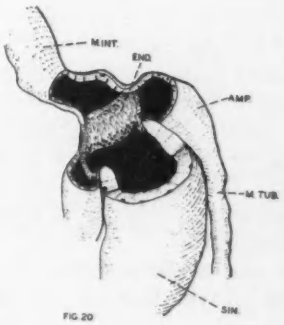


FIG. 20

# THE EFFECTS OF TEMPERATURE AND MOISTURE ON THE DISTRIBUTION OF THE MEXICAN BEAN BEETLE, EPILACHNA CORRUPTA, MULS.*

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It is well known that various species of plants and animals are found in certain environments. Some have a much wider distribution than others but eventually a place is reached where each organism fails to maintain itself. The limiting factors may be physical or biotic, or both, and may vary from time to time. The physical environment is extremely important to all life, including man (Huntington, 1924). Poikilothermic organisms are much more subject to the influence of the physical environment than homoiothermic species. Among the physical factors, temperature and moisture are probably the most important to the great majority of organisms.

This paper was prepared in 1929 and presented as part of a doctorate thesis on March 1, 1930, but other duties have prevented publication until this date. The paper has been brought up to date.

## REVIEW OF LITERATURE.

A few workers (Marcovitch and Stanley, 1930; Miller, 1930; Sweetman and Fernald, 1930) have attempted to determine experimentally the limitations of temperature and moisture on the Mexican bean beetle. Sweetman and Fernald presented the most complete data showing the effects of temperature and moisture in controlled environments on the pest. Marcovitch and Stanley had much less data, especially for the egg stage, but their results, are in accord with known responses of the insect. Miller's results are confined largely to extreme high temperatures, with a wide range of humidities, for short exposures only.

A few workers have attempted to determine the probable future distribution of the bean beetle. Graf (1925) from a

*Contribution from the Entomological Laboratory of Massachusetts State College.

climatic study, considered that temperature and moisture were not of much importance in limiting distribution of this insect. The writer (Sweetman, 1929) demonstrated that temperature and moisture limitations for the pest are very important, and that an analysis of the eastern and western infestations clearly showed that the responses of the bean beetle to these factors were the same in both areas. Previously, a number of workers had considered the responses of the organism to climatic factors different in the two areas, although it was evident that the humid east was very suitable for abundance and distribution of the pest. This study showed also, that the eastern environment was more favorable than the general environment of its native region. The limitations in distribution were shown in several papers (Sweetman, 1929; 1931; Sweetman and Fernald, 1930). Marcovitch and Stanley (1930) predicted the probable future distribution for the United States from a mathematical formula based upon the temperature and precipitation relationships of the insect. A map is included in their paper showing their conclusions.

## SEASONAL HISTORY.

The adults of the Mexican bean beetle emerge from hibernation in the spring after the advent of warm weather and locate suitable food plants, principally beans. Egg-laying begins in about a week or ten days after the beetles appear; the egg generally being attached to the under surfaces of the leaves. The over-wintering adults may continue oviposition until August. Incubation of the eggs requires about one to two weeks. The larvæ feed upon the leaves and pods for about three to five weeks, then attach themselves to the leaves and pupate; the adults emerging eight to twelve days later. The number of generations in a season is dependent upon the climatic conditions and length of season, and will vary from one to several generations in different regions. The beetles enter hibernation in the fall in moist, protected places, remaining dormant or semidormant, depending upon the weather, until spring.

## DISTRIBUTION.

The area occupied by the bean beetle at present covers a large section in the United States and Mexico (Fig. 1). The

eastern infestation is almost continuous, the pest being present wherever beans are grown, while the western and Mexican infestation is composed of may isolated islands, depending upon the local environment. The insect is not a serious pest over much of Guatemala and Mexico, but is very abundant in several localities in the western United States (Sweetman, 1929). The southern limit of the known distribution of the bean beetle is in Guatemala and the northern limit in Canada and New England.

## EVIRONMENTAL REQUIREMENTS.

The following conclusions regarding environmental requirements of the Mexican bean beetle during the active season are based upon previous papers (Sweetman and Fernald, 1930; Sweetman, 1931; Pyenson and Sweetman, 1932). The statements concerning the inactive period are based on an earlier paper (Sweetman, 1929).

*Adults.*—A temperature of 37° C. killed the beetle in a few hours; 32° was unsuitable with high relative humidity and favorable with low humidity; 27° C. was suitable for heavy oviposition with humidity of 60 per cent or above and unfavorable with low humidity, but favorable for length of life with all humidities used; 22° C. was favorable with humidities of 40 per cent or above; and 17° C. with 50 per cent humidity was suitable for length of life, but very unsuitable for egg production, while lower temperatures prevented reproduction. The adults became quiescent in temperatures near 12° C. The bean beetle hibernates in moist rubbish or places and is capable of withstanding low winter temperatures. Moist conditions are essential for successful hibernation.

*Eggs.*—A temperature of 37° C. killed the embryos; 30° C. was very destructive if reached for more than a few hours daily; 30° C. with humidities above 60 per cent permitted about 25 per cent of the eggs to develop and hatch; 27° C. was suitable with humidities of 60 per cent or above and unfavorable with low humidity; 22° C. was very favorable with humidities of 60 per cent or above, but was less favorable with low humidities; 17° C. with humidities of 50 per cent or above was very favorable for good hatches, but development was very slow; 15° C. was unfavorable for growth in all humidities, but a low percentage hatched in high humidities; 12° C. and 7° C. killed the embryos in a few days in all humidity conditions.

*Larvæ and Pupæ.*—A temperature of 37° C. killed the larvæ in a few hours; 32° C. was very unfavorable, especially with high humidity; 27° C. was favorable with high humidity and unfavorable with low humidity; 22° C. was very favorable with all humidities used; 17° C. with 50 per cent humidity was very favorable for a high percentage maturing, but development was exceedingly slow. Marcovitch and Stanley found development extremely slow in 15° C. conditions with high humidities.

## METHODS OF ANALYSIS.

The practical value of laboratory work cannot be determined until the natural environment is analyzed. This can be done in several ways. Methods in which the total accumulated temperature, above the minimum effective temperature, the "Bioclimatic Law" of Hopkins (1920), or the faunal zones of Merriam (1898), are used, are not of much value in this study as moisture is not taken into consideration. The climograph method of Ball (1910) is of value as moisture can be plotted against temperature. The writer has used this method in comparing the distribution of the bean beetle in New England and Wyoming in recent papers (Sweetman and Fernald, 1930; Sweetman, 1931). Cook (1923) adopted a curve representing the optimum temperature and precipitation for the insect studied and superimposed this on the climograph, using this curve as a standard of comparison of climatic conditions in different areas. If more published records of humidity were available this would be an excellent way of comparing the various regions for the bean beetle. Marcovitch and Stanley have used a mathematical expression of temperature and precipitation to determine the suitability of the environments for the bean beetle. Humidity is a better measure to use since the moisture of the environment in laboratory experiments is usually recorded as relative humidity.

A number of excellent maps of temperature and moisture conditions in the United States have been prepared by Kincer (1922, 1928) and published in the Atlas of American Agriculture. This material seems to be the best available data, especially for humidity, for the purpose of this study. Figures 2 to 16 are taken from the Atlas of American Agriculture. The moisture and temperature records used west of the ninety-ninth meridian and east of the west coastal region are modified

from the originals and do not show variations due to local topography. High altitudes especially have been ignored as most of the cultivated land is 7000 feet or less above sea level. An attempt was made to show conditions in the figures that were representative of the cultivated area. Weather records show that the maximum humidity occurs in the early morning hours and the minimum in the early afternoon hours. The 8 a. m. records (Figs. 5–8) have been selected to show maximum humidity conditions. The minimum humidity conditions are shown in Figures 9 to 12. The 2 p. m. data (Fig. 9) are used for the average minimum January humidity, since this is very close to the minimum moisture conditions during the winter months.

### REGIONS OF THE UNITED STATES.

The United States is divided, for convenience of discussion, into regions as follows: Northeast, Gulf Coast, Upper Mississippi, Arid West, Southwest, and Pacific Coast regions (Fig. 1). These divisions are based upon temperature and moisture conditions in the various sections, with reference to the known distribution of the Mexican bean beetle.

*Northeast Region.*—This region comprises New England and New York (Fig. 1). It is a moist region having an annual precipitation of 35 to 50 inches (Fig. 2). Figures 9 to 12 show that the average minimum humidity exceeds 50 per cent during the summer months and is much higher in the winter time. Therefore the moisture environment in the Northeast will not ordinarily be low enough to be detrimental to the bean beetle. However, if the summer temperature becomes excessive the high humidity will be injurious to the insect. The winter temperature is shown in Figure 13 and the summer temperature in Figure 14. The bean beetle has demonstrated its abi ity to withstand low winter temperatures further west in the states along the northern margin of its present distribution. Most of Maine, the central portions of Vermont and New Hampshire, and most of northern New York do not have average summer temperatures above 18° C. (Fig. 14). The 18° C. line approximately marks the southern limit of the Canadian Zone (Merriam, 1898) for this part of the United States. In a recent paper (Sweetman and Fernald, 1930), a study of the probable bean beetle dispersal in New England was made by

determining the temperature and moisture conditions in the various faunal zones. It was concluded that the pest would be unable to maintain itself in economic abundance in the Canadian Zone of New England because of the low temperature. The average temperature for July, the hottest month, is 18° C. and the average daily maximum temperature is 24° to 27° C. (Figs. 15–16) indicating that the temperature does not become high enough for good larval development except for a few hours daily. In the southern portion of the Northeast the temperature and humidity conditions are favorable, according to laboratory results, for the economic abundance of the bean beetle Developments during the past two seasons have demonstrated the truth of this statement. The pest has not reached the northern economic limit in this section, but will not advance economically much further northward. The combination of high temperature and humidity might become unfavorable at times, but an examination of the weather records shows that extremely high temperatures are uncommon and of short duration. Maximum temperatures are ordinarily below 38° C. and unless continued for several successive days the temperature among the plants would not become excessive.

*Gulf Coast Region.*—This region (Fig. 1) has an annual precipitation exceeding 45 inches per year, except in the western part, with over 50 per cent of the rainfall occurring during the summer months (Fig. 2). The average monthly minimum humidity exceeds 50 per cent throughout the year (Figs. 9–12) and the maximum is 75 to 90 per cent (Figs. 5–8) with the percentage increasing as the coast is approached. Experimental results indicates that such moisture conditions would be favorable, unless the temperature becomes excessive. It is well known that the bean beetle has not successfully penetrated this region with the possible exception of Thomasville, Albany, and Americus, Georgia. Recent correspondence with Mr. Gill of the Georgia State Board of Entomology, shows that the beetle is not maintaining itself in economic abundance at Thomasville and probably has spread very little from the original place of infestation. Apparently the spread to Americus and Albany has been from the north and not from Thomasville. Thus far the damage in these communities is of little or no consequence. Further north the insect has spread very rapidly and is a pest in nearly every locality where it has become established. Several authors (Graf, 1922; Howard, 1924) have

suggested that the prevailing winds are favorable to northward dispersal. While it is true that the general direction of dispersal from northern Alabama and Georgia has followed the direction of the summer wind currents, it is also true that a similar spread northward has not occurred at Thomasville. The direction and velocity of the prevailing winds at Thomasville are similar to those of northern Alabama and Georgia (Figs. 3–4). Since this region is very moist and warm it is probable that the high temperature and high humidity are the controlling factors. The average summer temperature for the region ranges from 27° to 32° C. (Fig. 14) and the average daily maximum temperatures are between 32° and 38° C. (Figs. 15–16) during the summer months. It has been shown experimentally that such temperatures with high humidity are very unsuitable for the bean beetle. It is undoubtedly the high temperature aided by the high humidity that is restricting the southern distribution of the insect. It is very probable that no economic injury will occur at Americus, Albany, and Thomasville, with the possibility of these infestations being eradicated by the unfavorable environment. The beetle has been present in western Texas for many years, although it rarely becomes injurious and then only on the more humid and cooler years. The aridity and scattered cultivated areas in northeastern Texas, eastern Colorado, and western Kansas are probably sufficient to prevent the beetle from spreading eastward but this cannot be the reason for the failure of the beetle to pass down the Rio Grande, Pecos, and Colorado river valleys of western and southern Texas. The prevailing winds, if the beetles follow air currents, are not entirely favorable to dispersal toward the east (Fig. 3). Apparently the high summer temperature is the principal limiting factor as the temperatures are very high during July and August (Figs. 15–16). It is possible that the high winter temperature (Fig. 13) might be unfavorable to the bean beetle. The temperature along the coast and southern part of Florida is not so extreme and the pest may succeed in passing to the southern part of the State, where conditions would be more favorable. However, the damage there would not be as great as further north, where it is a severe pest at present.

*Upper Mississippi Region.*—This area comprises the humid portion of the Mississippi valley bounded by the present

infestation on the east and the ninty-ninth parallel on the west (Fig. 1). The average annual precipitation is about 50 inches on the southern margin of the zone and decreases to less than 30 inches on the northern border. The western edge has about 25 inches of rainfall (Fig. 2). The maximum humidity varies for the area from 75 to 85 per cent (Figs. 5–8) and the minimum from 45 to 70 per cent, except along the western border where the minimum reaches 40 per cent (Figs. 9–12). The average winter temperatures vary from 4° C. on the southern margin to —12° C. on the northern border, but the pest has shown its ability to withstand such temperatures further east and in the arid west, except possibly the extremes along the northern edge. The average summer temperatures range from 16° to 27° C. which would be favorable to the insect, according to experimental results, except in the northern portion (Fig. 14). The average daily maximum temperatures of 32° C. or more during July and August in the southern portions of Illinois, Missouri, and Kansas, and southward would be very unfavorable to bean beetle development (Figs. 15–16). The humid conditions combined with the high temperature are certainly important factors in limiting the economic distribution in this area. The average daily maximum temperature of the middle portion of the region as far north as southern Minnesota, varies from 27° to 32° C. (Figs. 15–16). The temperature conditions of this area are very similar to those in Indiana and Ohio where the bean beetle is a pest. The humidity and precipitation records are likewise similar except for a slight reduction west of the Mississippi river. When such units are compared the similarity of the temperature and moisture environments shows that the insect can spread a considerable distance westward unless restricted by other factors. Suitable hibernating places probably are lacking in the western level prairies of the zone. Short dry periods in the fall and winter may be sufficient to reduce the moisture in such places to a state dangerous for the bean beetle.

The possibility that the wind is an important factor in controlling the direction of dispersal, as reported by several workers, gains its best support here. The northeasterly direction of the summer winds (Fig. 3) of rather high velocity (Fig. 4) would be unfavorable for the westward distribution if the pest tends to travel with the wind.

*Arid West.*—The topography of the west is extremely varied (Fig. 1). Consequently the temperature and moisture conditions of the environment show very sudden variations because of the changes in altitude. The moist area in Idaho and Montana is included in this region as the warm season precipitation, from April to September inclusive, averages about 12 inches. With the exception of this moist portion the precipitation of the cultivated plains varies from 10 to 20 inches (Fig. 2). Average maximum humidities vary from 50 to 85 per cent (Figs. 5–8), but average minimum humidities range from 20 to 45 per cent for the greater part of the year (Figs. 9–12). Because of the extreme dryness the bean beetle is greatly handicapped and is unable to maintain itself over most of the territory where farming is dependent upon the natural rainfall. The temperature is extremely variable also, because of the uneven topography. The average summer temperatures are between 10° and 22° C. (Fig. 14), but the daily extremes are great and the maximum daily temperatures during July and August reach 22° to 38° C. (Fig. 15–16). Because of the aridity and consequent high evaporation, if moisture is present, the extreme summer temperatures are not so injurious to the bean beetle as in the humid east. The evaporation rates in the irrigated or moist fields during the warm weather are sufficient to greatly reduce the temperature among the plants. The pest would spread over most of the territory if the moisture was higher, but at present it is limited usually to river bottoms and irrigated sections. Most of the irrigated parts are too dry in winter for successful hibernation. The average winter temperatures range from —1° to —12° C. (Fig. 13). This would not be unfavorable for the beetle, except possibly in the extreme north, if the moisture conditions were suitable.

Probably suitable hibernation quarters are scarce in much of the plains region. The writer (Sweetman, 1929) has shown that the distribution of the insect in the western states is dependent upon the moisture of the environment. Undoubtedly many of the areas that are favorable during summer months because of irrigation are unsuitable during the winter because of the aridity.

*Southwest Region.*—This region comprises the area south of the thirty-seventh parallel (Fig. 1). The topography is much smoother and lower than in the Arid West, consequently

environmental conditions are more uniform. The average annual precipitation varies from 5 to 20 inches (Fig. 2). The average maximum humidity ranges from 45 to 80 per cent (Figs. 5–8), but the average minimum humidity varies from 15 to 40 per cent most of the year (Figs. 9–12). This produces a very unfavorable moisture environment for the pest except along streams and in irrigated fields. The average summer temperature varies from 16° to 27° C. (Fig. 14), but maximum temperatures range from 27° to 43° C. (Figs. 15–16), which produce unfavorable temperature conditions except where evaporation from moist fields reduces the temperature. Winter average temperatures vary from —1° to 10° C., so are favorable, unless too high near the Mexican border (Fig. 13). The dry and hot conditions make the general environment unfavorable for the bean beetle, but the pest is able to maintain itself in small local environments. At times it is a very severe pest in irrigated fields and on moist years on the non-irrigated crop. This was shown very clearly by the writer (Sweetman, 1929) in a recent publication. Frequently the beetles must migrate to nearby foothills to locate suitable hibernation places. Apparently the beetle has reached the maximum economic spread in this region.

*Pacific Coast Region.*—This region comprises the western portions of Washington, Oregon, and California as far south as the thirty-seventh parallel (Fig. 1). The average annual precipitation exceeds 60 inches per year over most of the area (Fig. 2). Twenty to thirty per cent of the rainfall occurs during the warm season from April to September. The maximum humidity varies from 70 to 90 per cent (Figs. 5–8), and the minimum from 40 to 75 per cent (Figs. 9–12). The temperature is very uniform and the daily extremes are close together. The mean summer temperatures are 13° to 18° C. except in the south where the mean is 21° C. (Fig. 14), and the winter temperatures are 2° to 6° C. (Fig. 13). The average daily maximum temperatures vary from 16° to 27° C. (Figs. 15–16). Ordinarily, the humidity would be favorable for summer development because of the moderate temperatures. While growth might be slow, the long season would partially offset this. The bean beetle can be expected to become a moderately severe pest in the Pacific Coast Region if it becomes established.

## DISCUSSION.

The present and probable future distribution of the pest is shown in Figure 1. This figure should be used in conjunction with the conclusions of this paper. Marcovitch and Stanley (1930) show a similar map in their paper. The two figures are very similar, except that the writer has restricted the economic distribution somewhat more than Marcovitch and Stanley. The latter authors used precipitation records while the writer used relative humidity as the measure of the moisture conditions of the environment. Probably the temperature extremes have been considered as having a more pronounced effect also by the writer. The striking resemblance of the general conclusions from the two sources reemphasizes the importance of temperature and moisture as limiting factors in the economic distribution of the Mexican bean beetle. This fact was brought out by the writer in 1929, when it was shown that the abundance and distribution of the pest in both the East and the West was dependent upon the physical factors, temperature and moisture.

## CONCLUSIONS.

The following conclusions are limited to the effects of the temperature and moisture conditions in the various regions. Other factors, as food, may influence abundance and distribution also, but are not considered in this paper. Small isolated areas undoubtedly exist in many places that may appear to be exceptions to the general statements. All statements regarding distribution refer to the economic status of the nsect only, and not to taxonomic distribution. The map (Fig. 1) should be used in connection with the following conclusions.

*Northeast Region.*—Moisture conditions in this area are suitable for bean beetle development. The temperature conditions are favorable in the southern portion and unfavorable in the northern part. Therefore the bean beetle will be a pest in Connecticut, Massachusetts, most of New York, and the southern portions of Vermont, New Hampshire, and Maine. It will not be a pest in northern New York, approximately the northern halves of Vermont and New Hampshire, and most of Maine.

*Gulf Coast Region.*—Moisture conditions in this section are suitable except in the western part. However, temperature is

largely the controlling factor in these states. The high summer temperatures, combined with the high humidity, will prevent economic damage in the portions of Texas, Oklahoma, Arkansas, all of Louisiana, the portions of Mississippi, Alabama, and Georgia in this zone, a small portion of South Carolina, and the part of Florida not included below will be very unfavorable for the bean beetle. A narrow strip along the coast of the northern half of Florida and a similar narrow strip in South Carolina and Georgia may be sufficiently favorable to permit occasional damage from the pest. The southern half of Florida is suitable for damage to be produced by the pest.

*Upper Mississippi Region.*—Moisture conditions are favorable in the zone except along the western margin, where lack of moisture will partially check the pest during the growing season and while in hibernation. The high temperature in Arkansas, Oklahoma, southern Kansas, southern Missouri, and at times in southern Illinois will practically control the pest. Indiana, Illinois, northern Missouri, Iowa, southern Michigan, southern Wisconsin, and southern Minnesota will be favorable to the bean beetle. The insect will be partially checked in central Missouri, northeastern Kansas, eastern Nebraska, eastern South Dakota, Central Minnesota, northern Wisconsin, and northern Michigan. The latter portion of the zone may have severe damage at times during favorable seasons, but the pest will practically disappear during unsuitable seasons. The low temperature in northern Minnesota will prevent the economic establishment of the pest. A great deal of the resistance for the region will occur during the winter months. The dispersal will be slow over this region.

*Arid West.*—Natural moisture conditions throughout the cultivated portions of the region are unfavorable to the pest during the summer months. Irrigation will render many cultivated areas favorable for the developmental stages, but suitable hibernation places will not be available over much of the territory. The mountains should produce good hibernation places in Colorado, Wyoming, Utah, Montana, Washington, Oregon, and Idaho where they border irrigated plains or moist valleys. The aridity and high temperature will prevent the spread through the eastern edge of Colorado and western Kansas. Elsewhere the pest will be unable to maintain itself in the arid region. The general unfavorableness of the climate

indicates that some of the western infestations could be eradicated without great expense or labor. This is especially true of outlying infestations as the ones in Wyoming and Nebraska.

*Southwest Region.*—The bean beetle has been limited for many years in western Texas and western Arizona. The high temperature and low humidity are both very unfavorable and prevent the pest from spreading eastward through Texas and westward into Arizona, California, and Nevada. The beetle is not an economic pest over much of this area.

*Pacific Coast Region.*—Humidity conditions in this region are largely favorable, although summer precipitation is low. The low average mean temperature prevents dry weather from being as serious as in the Arid West and Southwest regions. Although the low temperature will reduce the rate of development of the insect, it can be expected to be an important pest, but not as severe as in the East.

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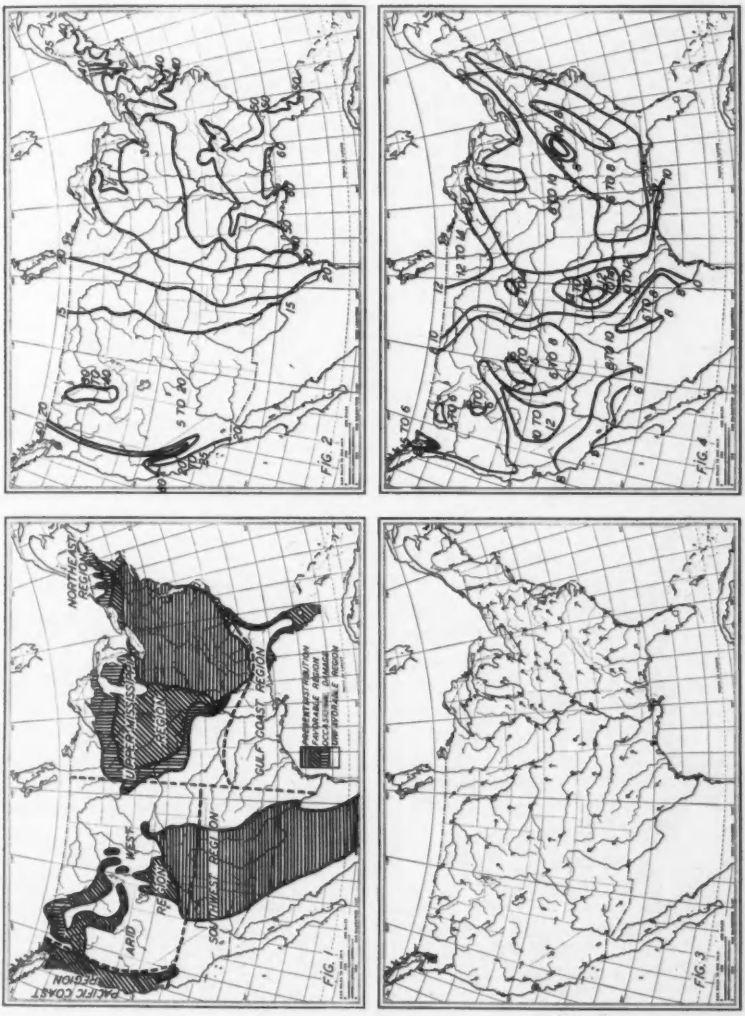


FIGURE 1. The regions of the United States and the present and probable future distribution of the Mexican bean beetle. (See conclusions also.)
FIGURE 2. The average annual precipitation in inches in the United States.
FIGURE 3. The prevailing direction of surface winds during July in the United States.
FIGURE 4. The average velocity in miles per hour of the wind during the year in the United States.

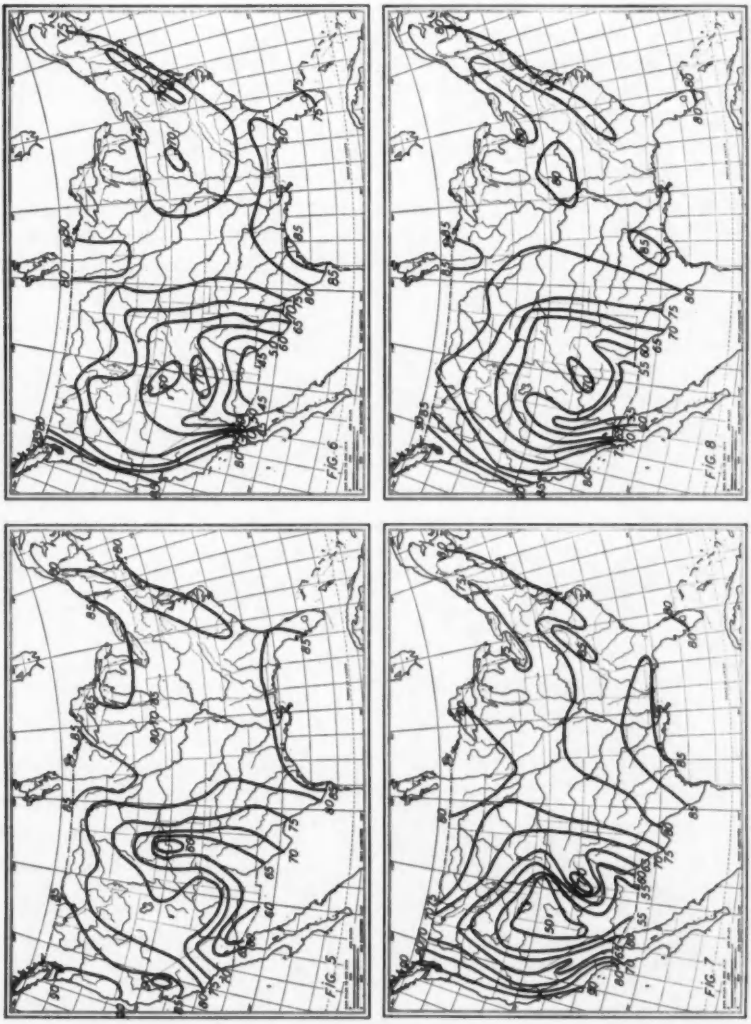


FIGURE 5. The average relative humidity at 8 a. m. (maximum) during January in the United States.

FIGURE 6. The average relative humidity at 8 a. m. (maximum) during April in the United States.

FIGURE 7. The average relative humidity at 8 a. m. (maximum) during July in the United States.

FIGURE 8. The average relative humidity at 8 a. m. (maximum) during October in the United States.

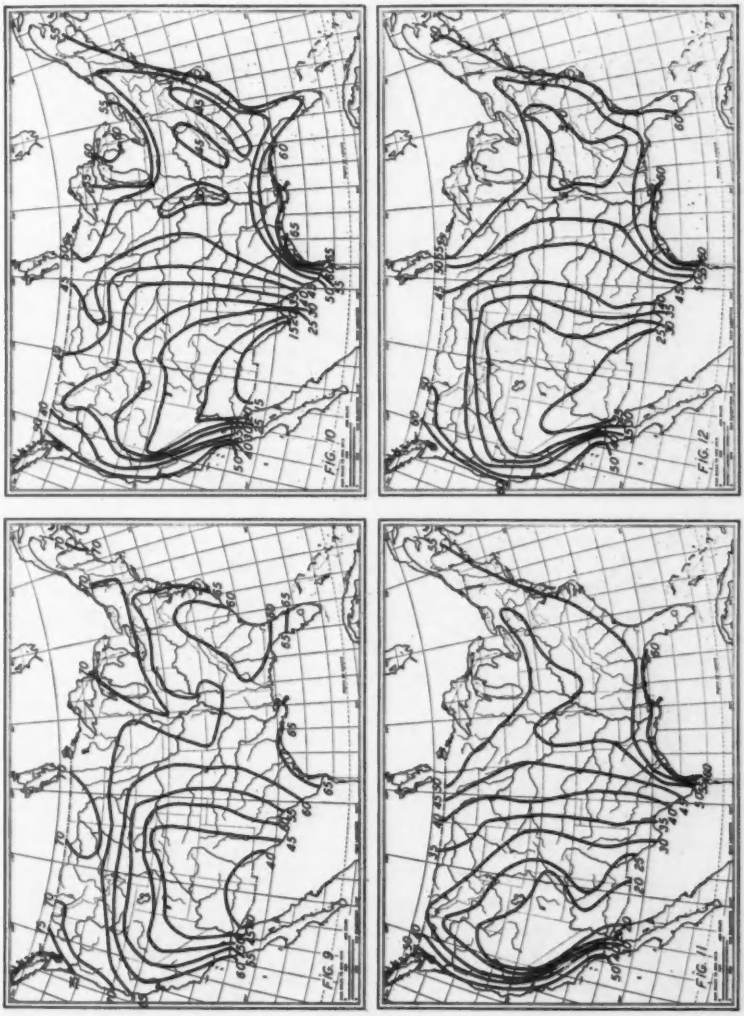


FIGURE 9. The average relative humidity at 2 p. m. (minimum) during January in the United States.

FIGURE 10. The average minimum relative humidity during April in the United States.

FIGURE 11. The average minimum relative humidity during July in the United States.

FIGURE 12. The average minimum relative humidity during October in the United States.

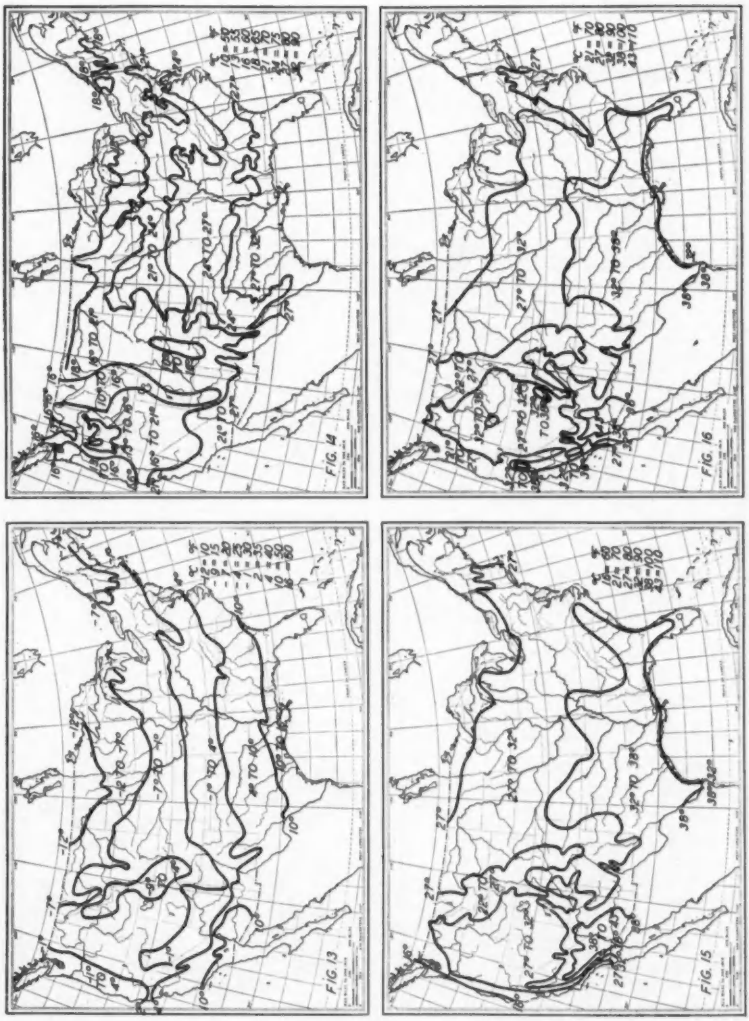


FIGURE 13. The average winter temperature from December to February, inclusive, in the United States.

FIGURE 14. The average summer temperature from June to August, inclusive, in the United States.

FIGURE 15. The average daily maximum temperature during July in the United States.

FIGURE 16. The average daily maximum temperature during August in the United States.

# THE PROBOSCIS RESPONSE OF INSECTS, WITH SPECIAL REFERENCE TO BLOWFLIES.

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## GENERAL CONSIDERATIONS.

The proboscis response of insects may be defined as an extension of movable mouth-parts in the presence of certain stimuli. The term "proboscis response" is properly applicable to insects possessing a retractile sucking tube, and hence is confined to such forms as Hemiptera, Homoptera, Lepidoptera, and Diptera.

The mechanism involved in this group of reflexes must vary greatly in different forms, and in most of these careful studies remain to be made. In the case of blowflies (*Calliphora erythrocephala*), however, Graham-Smith (1930) has described in detail the arrangement and working of parts.

Although this response must have been superficially recognized for a long time, the first extensive use of it for investigation appears to have been made by Minnich, who, in 1921, published data or this response in connection with experiments on the tarsal chemical sense of butterflies. In 1924 the same author made use of the same response in the study of the olfactory sense in *Pieris rapae* L.

Various stimuli serve to initiate the proboscis response. About 1910 Howlett pointed out that the feeding of mosquitoes is initiated by heat radiation. Verlaine (1927) brought about this response in *P. rapae* by breathing on the animal, by mechanical shock, and by various chemical stimuli. The stimuli that most frequently bring about this response in a wide variety of insects are chemical. Experiments carried on by the author during the summer of 1930 on *Stomoxys calcitrans* indicate that the biting of this species is initiated by the odor of perspiration; certainly neither heat radiation nor the odor of blood have much to do with it. Many Hemiptera, among them *Anasa tristis*, respond to chemical emanations by proboscis extension.

According to Forel (1908), any response of an organism to chemical emanations from a distant source constitutes a reliable evidence of olfactory perception. It is Forel's contention that the olfactory organs of insects are exclusively antennal, a contention supported by quite a number of competent entomologists.

It is not my purpose to review all the literature dealing with the problems of insect olfaction. This has been done by Minnich (1929). I merely want to point out that, as an indicator of olfactory powers, the proboscis response is probably the most reliable so far discovered.

There are several facts, at least in the case of flies, that indicate the purely olfactory nature of proboscis extension:

1. Flies (and many other insects) often regurgitate liquid simultaneously with the extension of the proboscis; this reaction takes place in normal feeding.
2. Insects affected by irritants (such as formaldehyde) rub the legs together and perform other typical movements not found in a purely olfactory response.
3. Irritants generally shorten the lives of insects exposed to them. This is not true of chemical compounds producing a purely olfactory response.
4. With few exceptions (formaldehyde), irritants drive away flies. This is not true of olfactory stimulants, which usually attract, and never repel, free insects.

## ORIGINAL EXPERIMENTS.

Preliminary experiments were performed on *Cynomyia cadaverina* to determine what substance might prove a satisfactory stimulating agent. Each fly was fastened by its wings, which were raised vertically over its dorsum and attached by means of warm paraffin to the end of a match stick. The insect was then lowered into a wide-mouthed bottle containing a bit of filter paper moistened with a few drops of the test substance. In this way the insect was surrounded by a vapor of the test substance. If the proboscis was extended within thirty seconds, the result was considered positive. The percentage of response was based upon the total number of insects responding. Between tests a "recovery period" of two minutes was allowed. The test substances used were geraniol, cymene, eugenol, and oils of tansy, sassafras, clove, wormseed, aniseed, and lemongrass. Fifty-five flies were tested.

The most effective stimulating agent proved to be tansy oil, to which eighty percent of the flies responded.

Rather by accident than design the discovery was made that the severed heads of living flies gave a proboscis response to chemical stimulation. This suggested the following experiment: the head was quickly severed with a pair of sharp scissors and so attached to warm paraffin on the end of a stick that the cut surface was sealed. All heads that thrust out the proboscis when cut were discarded. The others were tested in the same manner as the normal flies. In all, 147 heads were thus tested.

Sixty-seven percent responded positively.

Such a high percentage of response suggested that the antennae might be olfactory. The following experiment was performed to test this.

The flies used were *Lucilia sericata* Meig. (The warm weather destroyed the breeding specimens of *C. cadaverina*. Such a change in species does not necessarily invalidate results, since all blowflies are pretty much alike in their feeding reactions). The flies were etherized and "mounted" on the end of a stick. By means of a fine camel's-hair brush the antennae were covered with shellac. The operation was performed under a binocular magnifier. The test substance used was *ethyl butyrate*, a chemical having (as determined by previous experiment) about the same stimulating value as tansy oil. The flies were then allowed several hours to recover from the various operations. They were then tested in the usual manner. Sixty flies were tested.

Seventy-six percent of the insects responded positively.

## DISCUSSION OF RESULTS.

The high degree of response in flies tested under such diverse conditions as those given above argues against the possibility of eliminating olfactory sense organs by the methods employed. The responses of the severed heads indicates the presence of a complete reaction system independent of the big body ganglion. That certain nervous impulses should pass through the head alone is quite in keeping with the low integration of the insect nervous system. This type of behavior also tends to disprove the contention of McIndoo (1918) that the olfactory organs are distributed principally on other parts of the body. On the other hand, the claim that the olfactory sense is exclusively antennal is scarcely supported by the data.

The palpi and labella may have an olfactory function; a function which the above tests could not exclude. The palpi are known to contain sense organs which, like those of the antennae, lie in pits. Graham-Smith (1930) has also found two types of single sense organs in the labella of *C. erythrocephala*. It is conceivable that these last may be gustatory, but an olfactory function has not been contended.

## CONCLUSIONS.

1. The proboscis response is a characteristic reaction of insects with extensible sucking mouth-parts.
2. This response is initiated by one or more stimuli, the more important of which are chemical.
3. The perception of chemicals is olfactory.
4. In Diptera the nervous mechanism of this response is complete in the head, but this does not preclude the possibility that the sensory part of the mechanism exists elsewhere.
5. The sensory elements involved are not exclusively antennal.

I want to thank Dr. W. M. Barrows and especially Dr. D. F. Miller for suggestions and assistance in the experimental portion of this work.

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# PROCEEDINGS OF THE TWENTY-SIXTH ANNUAL MEETING

## New Orleans, Louisiana, December 29th and 30th, 1931.

The Twenty-sixth Annual Meeting of the Entomological Society of America was held at New Orleans, Louisiana, Tuesday and Wednesday, December 29 and 30, 1931. The program included 27 interesting papers covering nearly every phase of entomology and, in addition, the usual annual invitational address and symposium. Approximately 150 members attended one or more sessions.

The Annual Public Address was given by F. C. Bishopp, in the Municipal Auditorium and was attended by 350 persons. The subject of the address, which was illustrated with lantern slides, was "Waging War on Insect Enemies of Man and Animals," and was enjoyed by all.

The symposium on "Blood-Sucking and Non-Blood-Sucking Flies in Relation to Human Welfare," was presented effectively by F. C. Bishopp, H. H. Schwardt, E. H. Hinman and W. B. Herms, and was very completely and forcibly summarized by Dr. Ernest Carroll Faust of the Tulane University School of Medicine.

### Opening Session, Tuesday Morning, December 29.

The Society was called to order shortly after 10:00 A. M., by President J. W. FOLSOM in Lounge No. 1, Municipal Auditorium, New Orleans, La. The following papers were presented:

1. Observations on the Flight of Noctuid Moths. W. W. STANLEY, Tennessee Agricultural Experiment Station.
2. Responses of Blowflies to Odors in a Wooden Olfactometer. (Lantern.) N. E. MCINDOO, U. S. Bureau of Entomology.
3. Progressive Changes in the Components of Insect Populations. (Lantern and Moving Pictures.) C. T. BRUES, Harvard University.
4. *Habrobracon brevicornis* and *Ephestia kuehniella*—A Study in the Temperature Relationships of Parasite and Host. (Lantern.) NELLIE M. PAYNE, Kansas State College.
5. The Determination of Total Blood Volume in the Cockroach, *P. fulginosa*, with Special Reference to Method. (Lantern.) J. FRANKLIN YEAGER and OSCAR E. TAUBER, Iowa State College.
6. Observations on Late Fall Activity and Spring Emergence of the Hessian Fly in Iowa. (Lantern.) C. J. DRAKE and G. C. DECKER, Iowa State College.
7. Variation in *Aphis gossypii* Glover. (Lantern.) ROBERT E. WALL, Montana Agricultural Experiment Station.
8. The Morphology of the Head-Capsules of Some Coleopterous Larvae. (By Title.) W. E. WHITEHEAD, Macdonald College.
9. Further Notes on the Morphology of the Opostegidae (Lepidoptera, Tineoidea). (Lantern and Micro-projection Pictures.) JOHN R. EYER, New Mexico State College.
10. The Larvae of the Fungus-growing Ants. (Lantern.) GEORGE C. WHEELER, University of North Dakota.

The following committees were appointed by President Folson:

*Nominating Committee*—C. T. BRUES, Chairman; H. E. EWING, T. H. FRISON.
*Auditing Committee*—D. M. DELONG, Chairman; H. O. DEAY, C. M. PACKARD.
*Resolutions Committee*—E. D. BALL, Chairman; S. B. FREEBORN, F. A. FENTON.

**Second Session, Tuesday Afternoon, December 29.**

The Society was called to order by President Folsom at 1:45 P. M. The following symposium was presented:

BLOOD-SUCKING AND NON-BLOOD-SUCKING FLIES IN RELATION TO HUMAN WELFARE.

a. Myiasis-Producing Diptera. F. C. BISHOPP, U. S. Bureau of Entomology.
b. Blood-Sucking Flies, Exclusive of Culicidae. H. H. SCHWARDT, University of Arkansas.
c. Mosquitoes in Relation to Human Welfare. E. H. HINMAN, Tulane Medical School.
d. Flies as Mechanical Vectors of Disease-Producing Organisms. W. B. HERMS, University of California.

CONCLUDING REMARKS. ERNEST CARROLL FAUST, Tulane University School of Medicine.

Following this interesting and excellently presented symposium two papers from the general program were scheduled:

11. Identification of Chironomid Egg Masses. II. (By Title.) HAZEL E. BRANCH, University of Wichita.
12. The Dangers of Spider Bites. EMIL BOGEN, Olive View Sanatorium, Olive View, California.

President Folsom appointed G. A. DEAN, W. B. HERMS and D. M. DELONG to act as alternates on the Executive Committee which met immediately following the afternoon session.

**Third Session, Tuesday Evening, December 29.**

The Society was called to order by President FOLSOM shortly after 7:30 P. M., in Municipal Auditorium. The President then introduced F. C. BISHOPP, who gave the Annual Public Address. MR. BISHOPP's address, which was illustrated, was on "Waging War on Insect Enemies of Man and Animals."

**Fourth Session, Wednesday Morning, December 30.**

The Society was called to order by President FOLSOM. The following papers were presented:

13. Notes on the Life History and Thoracic Development of *Oligotoma texana* (Mel.) (Embiidina). (Lantern.) HARLOW B. MILLS, Iowa State College.
14. Biology of *Tabanus atratus* Fab. and *Tabanus trimaculatus* P. de B. (Lantern.) H. H. SCHWARDT, University of Arkansas.
15. The Salt Marsh Sand-Fly Problem (Culicoides). (Lantern.) W. E. DOVE, D. G. HALL and J. B. HULL, U. S. Bureau of Entomology.
16. The Relationship Between Climate and Abundance of the Boll Weevil. (Lantern.) DWIGHT ISELY, University of Arkansas.
17. The Association of the Apple Maggot, *Rhagoletis pomonella* Walsh, with a Bacterium Parasitic on Apple. (By Title.) A. A. GRANOVSKY, University of Minnesota.
18. Insect Names Commonly Mispronounced. A. L. MELANDER, City College of New York.

19. Two Species of Anacentrus Attacking Sugarcane Rootstocks in Louisiana, with Description of a New Species. W. E. HINDS, B. A. OSTERBERGER, L. L. BUCHANNAN, Louisiana Agricultural Experiment Station.
20. A Study of the Notonectidae. (Lantern.) H. B. HUNGERFORD, University of Kansas.
21. The Four Quarters of the Agrotinae. (Lantern.) WM. T. M. FORBES, Cornell University.
22. The Genus Acanalonia in North America (Homoptera, Fulgoridae). (By Title.) KATHLEEN C. DOERING, University of Kansas.

**Fifth Session, Wednesday Afternoon, December 30.**

The Society was called to order by President FOLSOM. The following papers were presented:

23. A Key to the Principal Families of Nymphs of Hemiptera. R. M. DECOURSEY, Connecticut Agricultural College.
24. The Chrysopidae of Canada. (Lantern.) ROGER C. SMITH, Kansas State College.
25. Gall Insects and Insect Galls. (Lantern.) E. P. FELT, Bartlett Tree Research Laboratories.
26. Collecting the Rare Grylloblattidae in the Northwest. (Lantern.) R. H. BEAMER, University of Kansas.
27. The Genus Tinobregmus. (Homoptera, Cicidellidae.) (Lantern.) PAUL B. Lawson, University of Kansas.

The Annual Business Meeting followed:

## REPORT OF THE SECRETARY.

Previous to July 1, 1931, the following, having been duly nominated and recommended, were elected members of the Society by mail ballot of the Executive Committee:

O. W. BRANDHORST, 225 Lister Bldg., 4500 Olive St., St. Louis, Mo.
ROBERT E. BUGBEE, 454 N. Main St., Meadville, Pa.
M. T. CHEO, Dept. Entomology, Cornell University, Ithaca, N. Y.
FRED WALKER FLETCHER, State College of Forestry, Syracuse, N. Y.
MISS A. LLOYD HORD, 146 W. Walnut Lane, Germantown, Philadelphia, Pa.
EDWIN W. HOWE, 2303 W. Douglas Ave., Wichita, Kans.
THOMAS BENJAMIN KERN, 740 N. Main St., Bethlehem, Pa.
CHARLES ALEXIS LORING, Cole Ave., Highland, Calif.
T. P. O. MENZIES, Curator, City Museum, Vancouver, British Columbia, Canada.
HAROLD IRVIN O'BYRNE, 501 Pacific Ave., Webster Groves, Mo.
ROGER L. PRESTON, 303 S. Madison St., Bloomfield, Iowa.
HUGO GEORGE RODECK, Department Biology, University of Colorado, Boulder, Colo.
E. J. SCHAEFER, 4471 N. Farwell Ave., Milwaukee, Wis.
J. W. SKINNER, Tex. Mex. Ind. Inst., Kingsville, Texas.
FRANCIS H. SUMNER, 760 University Ave., Palo Alto, Calif.
I. R. WATTS, 900 E. Sixty-first St., Cleveland, Ohio.

With the approval of the Executive Committee, F. C. BISHOPP was invited to give the Annual Public Address of the Society at the New Orleans meeting.

DR. W. E. HINDS kindly consented to act as chairman of the Arrangements Committee for the New Orleans meeting. The two other members of the committee were T. E. HOLLOWAY and E. R. BARBER.

DR. HAROLD MORRISON was appointed by PRESIDENT FOLSOM to represent the Society at the meeting of the Union of Biological Societies, held in Washington, March 7.

The following committee was appointed to arrange itineraries for the International Entomological Congress to be held in Paris in 1932: O. A. JOHANNSEN, Chairman; F. E. LUTZ, and ALBERT HARTZELL.

The Executive Committee met at 4:30 P. M., December 29, in Room 207 of Municipal Auditorium, New Orleans, Louisiana, the following being present: J. W. FOLSOM and J. J. DAVIS; also G. A. DEAN, W. B. HERMS and D. M. DELONG as alternates designated by the President.

The following were elected to membership in the Society:

JAMES ALFRED ADAMS, Department of Zoology, Iowa State College, Ames, Iowa.
MARGUERITE BERTA BALDWIN, 2908 Channing Way, Berkeley, Calif.
DWIGHT F. BARNES, 712 Elizabeth St., Fresno, Calif.
MARSTON BATES, Museum of Comparative Anatomy, Cambridge, Mass.
LOGAN J. BENNETT, 3222 West St., Ames, Iowa.
EMIL BOGEN, Olive View Sanatorium, Olive View, Calif.
LAWRENCE A. CARRUTH, Department of Entomology, Cornell University, Ithaca, N. Y.
J. R. DENIS, Laboratorie Arago, Banyuls-sur-Mer (Pyr-Or.), France.
L. P. DITMAN, University of Maryland, College Park, Md.
HEBER C. DONOHOE, 712 Elizabeth St., Fresno, Calif.
RAYMOND E. DOUGLAS, 302 Bryant Ave., Ithaca, N. Y.
RICHARD DOW, 12 Andover Hall, Cambridge, Mass.
BYRLEY FLOYD DRIGGERS, New Jersey Agr. Exp. Sta., New Brunswick, N. J.
CLEMENTS ELLIOTT, Box 376, University Station, Baton Rouge, La.
MILTON DYER FARRAR, State Entomology Bldg., Urbana, Ill.
ROBERT STERLING FILMER, Rutgers University, New Brunswick, N. J.
DAVID E. FOX, JR., Box 100, Twin Falls, Idaho.
GEORGE E. GOULD, Department of Entomology, Agric. Expt. Sta., Lafayette, Ind.
MRS. LEONE HARDING, Stuttgart, Ark.
ROBERT R. HEATON, Rushville, Ind.
LYMAN S. HENDERSON, 1042 Ohio St., Lawrence, Kans.
LAWRENCE ANDREW HETRICK, JR., Box 376, University Station, Baton Rouge, La.
F. P. IDE, Department of Biology, University of Toronto, Toronto, Ont., Canada.
CLYDE HENRY JOHNSTON, Box 542, University Station, Baton Rouge, La.
RALPH H. LEWIS, Todd Union, University of Rochester, Rochester, N. Y.
LLEWELLYN LLOYD, University, Leeds, England.
CLAY LYLE, A. & M. College, Miss.
G. ALLEN MAIL, Department of Entomology, Montana Agr. Exp. Sta., Bozeman, Mont.
PAUL MARTIN, Casilla 112, Lima, Peru.
ALBERT CURTIS MILLER, 381 W. Ninth Ave., Columbus, Ohio.
C. B. NICKELS, Box 209, U. S. Bureau of Entomology, Brownwood, Texas.
JOHN HARVEY ROBERTS, Box 376, Louisiana State University, Baton Rouge, La.
HERBERT H. ROSS, Illinois St. Nat. Hist. Survey, Urbana, Ill.
ROBERT LEE ROUDABUSH, Zoology Department, Iowa State College, Ames, Iowa.
MILTON W. SANDERSON, 1919 Vermont St., Lawrence, Kans.
W. D. SARGENT, Department of Entomology, Cornell University, Ithaca, N. Y.
CAMERON SIDDALL, Texas Experiment Station, College Station, Texas.
HERMAN T. SPIETH, Department of Zoology, Indiana University, Bloomington, Ind.
MORRIS A. STEWART, Rice Institute, Houston, Texas.
F. K. STOFFERS, 462 North 2 East, Logan, Utah.
AUGUSTUS R. SUMMEROUR, Box 90, Lucedale, Miss.
HERMAN DOUGLAS TATE, Dept. Zoology, Iowa State College, Ames, Iowa.
WYLIE L. THOMAS, Dept. Entomology, Utah State Agr. College, Logan, Utah.
FRIAR M. THOMPSON, JR., New Jersey Agr. Exp. Sta., New Brunswick, N. J.

GEO. A. THURBER, Insectary Bldg., Ames, Iowa.
PAUL A. WOKE, Box 291 Tallulah, La.
JAMES FRANKLIN YEAGER, Dept. Entomology, Iowa State College, Ames, Iowa.

Total new members for 1931—63.

Upon payment of $50.00, FRED C. HADDEN was elected to Life Membership.

The following were elected Fellows of the Society: C. N. AINSLIE, C. J. DRAKE, C. O. EDDY, W. P. FLINT, J. S. HOUSER, P. B. LAWSON, B. E. MONTGOMERY, DUDLEY MOULTON, C. H. RICHARDSON and R. C. SMITH.

On recommendation by the Executive Committee at the Cleveland meeting in 1930, and by vote of Fellows of the Society, DR. W. J. HOLLAND was elected Honorary Fellow of the Society. In acknowledging the election, DOCTOR HOLLAND wrote, under date of February 5, 1931, in part, as follows:

"Your letter reveals to me that I now become a member of a quintette, the other four members of which have been friends and associates for decades. My acquaintance with Howard began a few months after he commenced his labors under Riley at the United States Department of Agriculture, and the other gentlemen (Charles J. S. Bethune, J. H. Comstock, since deceased, and Herbert Osborn), whom you name in your letter, I may claim as almost life long friends.

"I very gratefully and sincerely desire to express through you to the Entomological Society of America my appreciation of the distinguished honor which my fellow workers have seen fit to confer upon me. It is grateful to an old man about to take his exit from life's stage to receive from his friends their plaudits and expressions of kind regard before the curtain drops."

The following have resigned during the year: R. T. DEGARNETT, A. L. BRODY, L. C. ELMORE, F. G. HOLDAWAY, C. F. JACKSON, A. E. MILLER, IVAN SHILLER, GEO. L. SMITH, S. V. WILBY, WM. WILD, T. E. SNYDER, GEORGIANA SWEET, G. A. FILINGER, MISS A. LLOYD HORD, L. J. MUSHMORE, P. W. MASON, J. C. OUELLET, S. A. RIFENBURGH, C. C. HILL, E. R. P. JANVRIN, and R. TAKAHASHI.

The following have been automatically dropped from the membership, either because of failure for three or more years to pay dues or because they cannot be reached: W. L. BAKER, J. BANGHART, F. BELON, G. A. BIEDERDORF, T. H. BURRIS, H. L. CHERMOCK, B. R. COAD, C. N. DAVIS, LORIN FIFE, A. J. FLEBUT, NORMA FORD, E. H. GIBSON, J. E. GRAF, M. L. J. HIGGINS, T. H. HUBBELL, R. F. HUSSEY, W. KNAUS, R. C. LANGE, ROBT. LATTIMORE, WM. F. LAWLER, JR., F. H. LETL, STEWART LOCKWOOD, W. B. MABEE, F. B. MAUGHAN, C. R. NEILLIE, A. M. RANDOLPH, C. F. ROSS, R. M. SEELEY, G. M. STIRRETT, H. F. STROHECKER, W. R. THOMPSON, P. A. TURNER, J. A. VELLARD and H. E. WOODWORTH.

The following were elected to the Editorial Board for the term expiring December 30, 1933: J. M. ROBINSON, G. M. LIST and C. E. MICKEL.

The resignation of J. M. ALDRICH as editor of the Thomas Say Foundation was accepted. DR. ALDRICH was recommended to the Society for the position of Editor Emeritus of the Foundation. J. J. DAVIS was elected Editor and Treasurer.

The Executive Committee by vote recommended that Section 4 of Article V of the Constitution be amended to omit the last sentence. This to be voted upon at the 1932 meeting.

The Executive Committee adjourned at 5:30 P. M.

The Society has suffered the loss by death of the following six members, during the past year:

JOHN HENRY COMSTOCK, charter member, honorary fellow and past president of this Society, was born in Janesville, Wisconsin, February 24, 1849, and died at his home in Ithaca, New York, March 20, 1931. He was indeed a self-made entomologist in all respects for he earned his own way through Cornell University and at a time when instruction in entomology, as such, was not given at that institution. In his junior year (1872) he so interested a number of students in insect study that they successfully petitioned the faculty to permit him to give them a course in entomology. Later a department was created for him with the

exception of brief periods of study at Harvard and Leipzig, a few years as entomologist for the federal government, and the time spent organizing the department of entomology at Stanford University, his long life was spent in the service of Cornell University. Here he trained men from all over the world for service in entomology and it is said that he taught entomology to more than 5,000 students. He retired from active teaching in 1914, but for a dozen years thereafter was actively engaged in the preparation of books which will ever stand as monuments to his productive life. He will always be known as one of the greatest teachers of entomology the world has produced and the many prominent entomologists who were his students and his several text books are living evidences of this fact.

He was claimed as a member, fellow or honorary member of many scientific societies, both in this country and abroad, and his achievements were appropriately recognized by zoologists and naturalists, as well as by entomologists. To a considerable degree he has been responsible for the development of entomology in this and other countries. In the words of one of his earlier pupils, "a great teacher has passed and left an enviable record. Professor Comstock endeared himself in a most charming way to all of his students. He exercised a very profound influence in establishing teaching standards for entomology. His writings are admirable models for his successors. His life was an inspiration to all searchers for truth, and an exemplification of possibilities in this land of equal opportunity." Another great teacher, our present president, uses these words: "We have lost a great teacher, but his enthusiasm and energy are still an inspiration to the many eminent entomologists who were guided by him."

ALFERDO FAZ, of Santiago, Chile, a member of our Society since 1923, died during the year. Senor Faz was a business man and little is known of his interests, but from information available he was a general collector and his personal collection consisted largely of showy and striking forms of insects.

PHILIP ROSEMONT LOWRY was born at Senecaville, Ohio, September 24, 1896, and passed away in his research laboratory at the University of New Hampshire from a sudden heart attack. He graduated from Ohio State University in 1920, receiving his Master's degree the following year. In the University he showed himself to be a high-minded boy with earnest, studious interests, yet with broad vision and with sympathetic human intuitions. In 1918 he enlisted for war service and was assigned to the hospital division, where he became a laboratory technician. He remained in the service until after the armistice, when he returned to complete his studies. In 1920 and in 1921 he held temporary appointments on the staff of the Ohio Agricultural Experiment Station. In 1921 he became assistant entomologist of the New Hampshire Agricultural Experiment Station and assistant professor of entomology at the University of New Hampshire, which positions he held until his death. He held membership in several scientific organizations, including this Society.

As a teacher, Philip Lowry gave himself without stint to his students. He was himself thorough and he trained thorough men, leaving nothing undone that could add to the equipment of those who came to him for instruction. As an investigator the same high standards were maintained. His contributions to productive research are evidenced by his publications and by the underlying body of accurate data that he accumulated throughout his ten years in research activities. He was a man of sterling and lovable character.

FREDERICK ARTHUR GODFREY MUIR was born in England, April 24, 1872, and died in his native country May 13, 1931. For many years he was in the service of the Eastern Telegraph Service in British provinces in Africa and India, although from an early age maintained an interest in insect study and made extensive collections as a pastime. In 1905 he was induced by David Sharp, his future father-in-law, to accept an appointment as assistant entomologist of the Hawaiian Sugar Planters' Association Experiment Station. His first notable achievements were the successful introduction into Hawaii of effective parasites of several destructive imported insects. Later he conducted researches on the morphology of genital structures and was the leading authority on the Fulgoroidea. In this group alone he published more than 100 papers. One who knew him writes: "Of quiet and modest, but genial bearing, he was most entertaining when he could be persuaded to relate his varied experiences of travel in the wild and remote regions

into which his researches had taken him." Another says, "Muir was personally the most kindly and friendliest of men. Utterly fearless, steadfast and true, his was an amazing vitality which enabled him to hold on where others would have given up." His premature death is a severe loss to entomology and to Homoptera taxonomy in particular.

FRIEDRICH RIS was elected a member of the Entomological Society of America in 1914. He was born at Glarus, Switzerland, January 8, 1867, and died at Rheinau, where he was Director of the Hospital for the Insane, January 30, 1931. Trained in medicine and in surgery at the University of Zurich, in psychiatry under August Forel, in neurology in Golgi's laboratory, his occupation in life was along these lines, but from early youth his interest in entomology was strong, especially in the Lepidoptera, Trichoptera, Plecoptera and Odonata. His most important publications concern the last-named group and comprise many faunal papers on different parts of the world and a great monograph of the subfamily Libellulinae (1909–1919), which forms a part of the Catalogue of the Zoological Collections of the Baron Edmond de Selys-Longchamps. By these Ris established the right to be considered the foremost authority of his time on the Odonata. Kindly, sympathetic, helpful, his death is keenly felt by all students of this group of insects.

JAMES WILLIAM SKINNER, born in Kentucky in 1855, died at his home in Kingsville, Texas, October 24, 1931. Ordained a minister of the Presbyterian Church in 1883, he served churches in Indiana, Illinois, Colorado and Texas until 1912, when he accepted the presidency of Texas-Mexican Industrial Institute, which office he held until his death. Doctor Skinner was interested in insect life as an important phase of nature study and our Society is proud to have had him as one of its members, even though it was less than a year ago that he accepted membership.

HENRY LORENZ VIERECK was born at Philadelphia, March 28, 1881, and was killed October 8, 1931, at Loudenville, Ohio, when struck by an automobile driven by a hit-and-run driver. During 1900–1902 he studied and worked at the Philadelphia Academy of Sciences as a Jessup student, and in 1902 entered Jefferson Medical College with the intention of studying medical surgery. He later became student assistant in the pathological laboratory of the Medico-Chirurgical College of Philadelphia, but finally gave up the idea of becoming a surgeon and devoted himself to entomology. His entomological activities comprised work with the New Jersey mosquito survey in 1903; assistant entomologist, Connecticut Experiment Station, 1903–05; in charge zoological laboratory, State of Pennsylvania, 1907–08; research entomologist, Parke, Davis and Co., 1908–1909; agent and expert, U. S. Bureau Entomology, 1909–13; assistant curator, Snow collection, Kansas University, 1913–14; entomological explorer and assistant superintendent state insectary, California State Commission of Horticulture, 1914–16; assistant biologist, U. S. Biological Survey, 1916–23; assistant entomologist, Canadian Department of Agriculture, 1923–26. Poor health, by which he had been handicapped for a number of years, finally forced him out of entomology and the last few years of his life were spent in retirement.

His published contributions, numbering around 60 titles and consisting almost entirely of taxonomic papers on Hymenoptera, contain descriptions of many species of bees, wasps and parasitic Hymenoptera from various parts of the world. His largest and best known contributions are probably the "Hymenoptera or Wasp-like Insects of Connecticut" and "Type Species of the Genera of Ichneumon Flies."

A man of many brilliant talents, Viereck will be known to the science of entomology principally through the many new genera and species which he described, but he will be remembered by his friends as a courteous, companionable and thoroughly likable individual as well.

ANDREW GRAY WEEKS, JR., well-known student of the diurnal Lepidoptera, died at his home in Marion, Massachusetts, December 7, 1931, at the age of 70 years. He was born in Boston, October 2, 1861, and received his A. B. degree from Harvard University in 1883. For twenty years thereafter he was engaged in business. In 1903 he was appointed honorary associate in entomology in the Museum of Comparative Anatomy.

Following the reading of these brief memorials the members stood in silence in memory of the eight members who have died during the past year.

Respectfully submitted,

J. J. DAVIS, *Secretary.*

On motion the Secretary's Report was accepted and the recommendations adopted.

## REPORT OF THE TREASURER.

### CURRENT FUNDS.

RECEIPTS.

| | |
|---|---|
| Balance, December 30, 1930 (See Annals XXIV, p. 189) | $2,586.69 |
| From Annual Dues of Members to December 21, 1931 | 2,384.40 |
| Received from C. H. Kennedy, Managing Editor of ANNALS | 1,600.00 |
| Interest on Liberty Bonds | 14.42 |
| Total | $6,585.51 |

EXPENDITURES.

| | |
|---|---|
| Lafayette Printing Co., Letterheads, Dues Cards, Nomination Blanks, Programs, Announcements, etc | $ 78.50 |
| Stamps and Stamped Envelopes | 66.66 |
| Zoological Record | 25.25 |
| Spahr & Glenn, Printing of Annals and Separates for December, 1930, March, June and September, 1931 | 4,117.95 |
| Refund on Dues and to Thomas Say Foundation | 5.50 |
| O. A. Johannsen, Expenses on International Congress Notices | 35.12 |
| Returned Checks | 16.00 |
| Telegrams | 1.32 |
| Clerical Services | 44.63 |
| Loan to Thomas Say Foundation | 200.00 |
| Miscellaneous Expenses, Including Rubber Stamps and Exchange on Canadian and Hawaiian Checks | 7.08 |
| Transferred to Permanent Fund, Interest on Liberty Bonds | 14.42 |
| Total | $4,612.43 |
| Balance in Bank | 1,973.08 |
| | $6,585.51 |

### LIABILITIES.

The Society owes the publishers for the December, 1931, Annals and a few miscellaneous expenses. Of the above cash receipts for dues, $1,164.00 is for 1932 dues.

### PERMANENT FUND.

| | |
|---|---|
| Liberty Bonds (Annals XXX, p. 202) | $ 350.00 |
| In Savings Account of Purdue State Bank, West Lafayette, Ind. (Annals XXIV, p. 189) | 2,418.69 |
| Interest on Liberty Bonds | 14.42 |
| Total | $2,783.11 |

### RESOURCES.

| | |
|---|---|
| Liberty Bonds | $ 350.00 |
| Savings Account, Purdue State Bank, West Lafayette, Ind | 3,475.24 |
| Balance in Checking Account, Purdue State Bank | 930.95 |
| Total | $4,756.19 |

Of the total resources, $2,783.11 is in the Permanent Fund and $1,973.08 in Current Fund—Total, $4,756.19.

Respectfully submitted,

J. J. DAVIS, *Treasurer.*

On notion the Treasurer's Report was accepted, subject to the approval of the Auditing Committee.

## REPORT OF THE MANAGING EDITOR OF THE ANNALS.

I wish to report that the financial curve of the ANNALS has had no dip paralleling the flat curves of other human enterprises of this year of depression. This office has had receipts of over $2,800.00 this year, which is nearly $500.00 more than for the year 1930. The volume for 1930 had 833 pages, for 1931 it had 940 pages and we plan for a volume of over 1,000 pages for 1932. Ten point type is being used more freely to crowd more material into each issue. A more uniform style of printing is being worked out. I wish to note a grant of $500.00 from the National Academy of Science given specifically for aid in publishing research in pure science. Enough material is on hand for the March, 1932, issue and more than half enough for the June, 1932, issue.

I wish to thank Professor Osborn for advice and assistance, Mrs. Elizabeth A. Davis for her capable assistance in mailing and bookkeeping and Spahr and Glenn, the printers, for their continued help in the make-up and proof reading.

The financial summary follows:

RECEIPTS.

| | |
|---|---|
| From authors for Etchings and Reprints | $1,206.06 |
| From Sale of Back Volumes, Numbers and Reprints | 504.34 |
| From Non-member Subscriptions | 586.55 |
| From National Academy of Science | 500.00 |
| Refund from Bucher Engraving Co | 80.57 |
| Total | $2,877.52 |

DISBURSEMENTS.

| | |
|---|---|
| Engravers' Bills | $ 715.76 |
| Stenographic Service | 238.66 |
| New Typewriter | 75.05 |
| Moving Annals Supplies to New Quarters | 45.69 |
| Fourth Class Postage on Four Issues | 59.35 |
| Stamps, Stationery, Express | 60.57 |
| Refunds and Exchange | 11.34 |
| To J. J. Davis, Treasurer | 1,600.00 |
| | $2,806.42 |
| Balance in Bank, December 18, 1931 | 71.10 |
| Total | $2,877.52 |

Vouchers are submitted herewith.

Respectfully submitted,

CLARENCE H. KENNEDY, *Managing Editor.*

On motion the report was adopted subject to the approval of the Auditing Committee.

## REPORT OF THE TREASURER OF THE THOMAS SAY FOUNDATION.

FOR THE YEAR 1931.

RECEIPTS.

| | |
|---|---|
| Balance on hand January 1, 1931 (See ANNALS XXIV, p. 191) | $ 887.14 |
| Received from Entomological Society of America as Loan | 200.00 |
| Interest on Savings to June 30, 1931 | 26.73 |
| Received from Sale of Volume I | 15.65 |
| Received from Sale of Volume II | 24.50 |
| Received from Sale of Volume III | 36.00 |
| Received from Foundation Fund | 7.00 |
| Total | $1,197.02 |

EXPENDITURES.

| | |
|---|---|
| Postage on Mailed Volumes I and II | $ 5.50 |
| Telegrams | .96 |
| Express and Other Transportation Charges | 2.69 |
| Binding 96 Copies of Volume I | 48.00 |
| Printing Advertisement Circular for Volume III | 25.76 |
| Interest on Loan from J. J. Davis for Printing Volume II | 19.50 |
| By Cash to Reduce Loan | 200.00 |
| To C. C. Thomas, Commission for Sale of 6 Books | 3.00 |
| | $ 305.41 |
| Balance in Purdue State Bank | 891.61 |
| | $1,197.02 |

There is a balance due on loan by J. J. Davis for printing Volume II of $125.00. Also, a loan of $200.00 owing the Entomological Society of America.

Respectfully submitted,

J. J. DAVIS, *Treasurer.*

On motion the Report was accepted subject to the approval of the Auditing Committee.

## REPORT OF THE AUDITING COMMITTEE.

We, the undersigned members of the Committee on Auditing, beg to report as follows, after careful examination of the books of the Treasurer, the Managing Editor of the Annals, and the Treasurer of the Thomas Say Foundation, have found them correct and properly balanced.

Respectfully submitted,

D. M. DELONG, *Chairman,*
H. O. DEAY,
C. M. PACKARD.

On motion the Report of the Auditing Committee was accepted.

## REPORT OF THE RESOLUTIONS COMMITTEE.

The Entomological Society of America wishes to express its appreciation and gratitude for the splendid arrangements which have been made for this meeting. We especially desire to express our appreciation, *first*, to the generosity of the city of New Orleans in providing facilities in the Municipal Auditorium for the several entomological meetings, and *second*, to the chamber of commerce and the

local committee for providing numerous facilities and entertainments which have added so much to the pleasure of those attending these meetings.

This Society also wishes to express its recognition of the untiring efforts on the part of our committee in arranging for American participation in The International Congress of Entomology to be held in Paris.

This Society also wishes to express its appreciation of the painstaking work of our local committee: DR. W. E. HINDS, T. E. HOLLOWAY and E. R. BARBER, for arranging the many details necessary for the consummation of this very successful meeting. Also to Mr. W. E. Haley who had charge of room arrangements at the Auditorium.

And finally your committee wishes to express the highest appreciation of the Society to J. J. DAVIS, retiring secretary, for his untiring attention to the development of this Society.

(Signed) F. A. FENTON,
S. B. FREEBORN,
E. D. BALL, *Chairman*.

By vote of the Society, the Report of the Resolutions Committee was accepted.

## REPORT OF THE NOMINATIONS COMMITTEE.

The Nominating Committee begs to report the following names as nominees for the respective offices for the year 1932:

*President*—J. J. DAVIS.
*First Vice-President*—F. C. BISHOPP.
*Second Vice-President*—W. B. HERMS.
*Secretary-Treasurer*—H. B. HUNGERFORD.
*Additional Members of the Executive Committee*—For the term expiring December 31, 1934: A. L. MELANDER and J. M. SWAINE.
*Councillor to the American Association for the Advancement of Science*—W. G. MARSHALL and W. E. BRITTON.

Respectfully submitted,

C. T. BRUES, *Chairman*,
T. H. FRISON,
H. E. EWING.

On motion the report was accepted and the Chairman of the Committee instructed to cast a ballot for the election of the persons nominated. This being done they were duly elected.

The Committee on Insect Collections reported as follows:

## REPORT OF THE COMMITTEE ON INSECT COLLECTIONS.

In presenting the report on insect collections it may be noted that there seems to be a continued policy on the part of those responsible for the building up of representative collections to give this important phase of entomological work its due recognition and to provide as fully as possible for the acquisition and preservation of typical or authentically identified series. That there should be a considerable degree of specialization is natural and appropriate and the publication of data showing the location of type material or of specialized collections is believed to be a convenience to entomological workers.

The following reports have been received and word from a number of other institutions to the effect that collections have not been of such nature as to be considered important to report.

*U. S. National Museum*, Washington, D. C.: While the collections in the National Museum are being steadily increased, no outstanding accessions have

been made during the current year. Dr. David C. Graham has continued his collecting in Western China and on the border of Thibet with the result that the Museum has received from him over 40,000 specimens of Insects for the year. Mr. D. S. Bullock has made several small but rather valuable donations during the year; these from Chile.

DR. J. M. ALDRICH, per MRS. WILLIS.

*Canadian National Collection:* Most of the additions to the collection that have been acquired since it was last reported in 1928 have come through faunal surveys conducted by the Entomological Branch. The most important of these surveys were carried on in the following regions: Canadian Labrador, Nova Scotia, New Brunswick, southern and western Quebec, southern Ontario, southern Alberta, and British Columbia. The groups in which more noteworthy additions have been made are as follows: Lepidoptera, Ephemeroptera, Coleoptera, Diptera, Hemiptera, and Homoptera. A large identified collection of immature Ephemeroptera has been acquired. Most of the types added to the collection during the past three years belong in the groups noted above and to the Hymenoptera. New steel cabinets containing 800 drawers have been acquired to care for this additional material. The collection was moved recently into new quarters which are ideal in every respect. At present the collection contains type material of 3,373 North American species.

J. MCDUNNOUGH.

*The American Museum of Natural History*, New York City: During the past year the American Museum collection of insects has been enriched by approximately 25,000 specimens. Outstanding among these is the C. H. Curran collection of Diptera which contains more than 10,000 specimens, including not only the types of many species described by Mr. Curran, but also type specimens from the collections of Stein, Becker, Keiffer and others. In all, more than 500 species are represented by type material. Other collections of note consist of 4,000 specimens received from the Chapin Congo Expedition, 4,000 collected by Mr. Curran in New York and New Jersey, 1,500 donated by Mr. E. L. Bell and more than 1,000 donated by Mr. Frank Johnson. The exhibition of live insects which has been carried on for the past three years has attracted many of the younger students in entomology to such an extent that almost every day, especially during the season of insect activity, one or more specimens are brought to the Museum either for identification or as additions to this exhibition.

MR. A. J. MUTCHLER, through FRANK E. LUTZ.

*The University of Nebraska:* The rearrangement of the insect collection, begun in 1929, has continued through 1931, and at the present time is about one-half completed. Considerable new material from Nebraska and adjacent states has been added during the year. Much attention has been given to the *Cicadellidae*, and the collection in this group is being completely rearranged and greatly augmented by Miss Dorothy Johnson. Messrs. Raymond Roberts and O. S. Bare continue their development of the collection of *Vespoidea* and *Formicoidea*, begun by them in 1929.

MYRON H. SWENK, *Chairman, Department of Entomology.*

*Alabama Polytechnic Institute*, Auburn, Alabama: With reference to the insect collection of our department I would say that during the past year Dr. Good has determined some three hundred species of Heteroptera. During the year we have carried on some exchange work and have added some two hundred species of beetles, mostly through exchange from the authorities at the University of California. Other exchange work is being contemplated through the remainder of this year.

J. M. ROBINSON.

*University of Kentucky*, Lexington, Ky.: Our insect collection consists of approximately 53,000 specimens. There are about 2,700 named species including several types and paratypes. This fine collection has been gathered and prepared almost entirely by Dr. Garman. Miss Didlake and other assistants have aided by occasional contributions of specimens.

W. A. PRICE.

*Utah Experiment Station:* During the year normal progress has been made in building up the general collection, about 7,000 pinned specimens having been added, in addition to 800 reared parasites, 1,000 Orthoptera and 1,500 slides of Thysanoptera. M. J. Janes added his collection of 1,700 specimens to the Station collection.

G. F. KNOWLTON.

*The North Carolina State College*, Raleigh, N. C.: This department has added large series of Homoptera during the past year from British East Africa, Brazil, Central America, Cuba, Mexico, and Philippines. It has made numerous additions to its drawings of Homoptera of the world, and also numerous additions to its index of Homoptera.

Z. P. METCALF.

*Brigham Young University*, Provo, Utah: The Entomological collections of this University have been materially increased this year due to a gift from Mr. D. Eldon Beck, who gave to the University 15,000 specimens which were collected in Iowa, Missouri, Oklahoma, Texas, and Mexico. The major portion of this collection consists of Coleoptera. There were also added about 2,000 specimens collected in the Uintah Mountains and about 1,000 specimens collected in the Teton National Park by the writer and his associates. About 1,500 specimens, collected at Cedar City, Utah, and Paris, Idaho, by Mr. C. Lynn Hayward, were added to our collection. This makes a total of about 95,000 specimens in the University collection.

VASCO M. TANNER.

*Clemson College, South Carolina* (the land-grant college): Our collections are intended to illustrate the state fauna as completely as possible, with card-catalogue in connection which gives many additional records. We use chiefly the Schmitt box at present, of which we now have about 350 in use—with some duplicate, surplus and class-work material in other types of containers. We have more than 2,000 species (est.) of identified insects in our collections, with a total state list now amounting to approximately 3,300 species. Progress has been good during 1931, though it is difficult to acquire sufficient boxes to keep pace.

FRANKLIN SHERMAN.

*Illinois State Natural History Survey*, Urbana, Illinois: The addition of 8,900 pinned specimens to the Survey collection records from a numerical standpoint our greatest progress this year. A 5,000 specimen increase due to collecting in various localities in the state by various members of the staff, a 2,000 specimen collection of general Hymenoptera donated by T. H. Frison, and 1,000 sawflies and the general collection, mostly Hymenoptera, of H. H. Ross, comprise the increment. A continuance of the work on the aphids of the state resulted in the addition of 1,400 new slides, increasing the slide collection of these insects to 13,400, including typic slides. Eleven hundred vials of specimens preserved in alcohol, nearly half of which is this year's new material, and 800 pinned specimens form the present Trichoptera collection. The series of type specimens was augmented principally in the families Aphiidae, Cynipidae and Tenthredinidae; 1,970 allotypes, morphotypes, paratypes and the like, and 89 holotypes or their equivalents having been added. The distribution of these types were as follows: 63 holotypic and 1,330 paratypic slides of Aphiidae, 26 holotypes and 505 paratypes of Tenthredinidae, 125 paratypes of Cynipidae, and 10 paratypes of miscellaneous groups. Adult and immature specimens of Plecoptera taken in various parts of Illinois form a 500 vial supplement to previous collections of these aquatic insects.

THEODORE H. FRISON.

*Massachusetts State College:* The most notable accession was the gift, by Dr. Henry T. Fernald, of the local collection of insects made by his mother, Maria S. Fernald. This extensive series is especially rich in material from Maine and Massachusetts. Other valuable specimens have been received through the kindly interest of Messrs. J. W. Angell, Charles A. Ballou, Jr., and C. A. Frost. My private collection of Tipulidae now totals 4,961 species, of which 3,727 are represented by type material, either holotype, allotype, or paratype.

CHARLES P. ALEXANDER.

*Colorado Agricultural College:* The collection is composed of about 150,000 specimens, most of which were taken in the state. About 85,000 specimens are determined and comprise approximately 10,000 species. The pinned specimens are contained in about 600 Schmitt boxes and 225 cabinet trays. Most noteworthy of mention would be 15,000 slides of Aphididae, of which 14,000 slides are determined. There are 509 species of aphids represented in the collection. During the past season about 4,000 specimens of Syrphidae were collected and 450 slides of Acarina prepared. A complete summer run of one light trap is being preserved and worked into the collection.

GEORGE M. LIST and SAM C. MCCAMPBELL.

*Museum of Comparative Zoology:* The collections are all moved to the rooms formerly occupied by the Zoological Department on the fourth floor. Here the walls are higher, the floors better, the light very much better, and with more space. The Leconte collection is in a small special room opening off the Coleoptera room. Aside from many smaller collections the additions are as follows: Several thousand specimens from Mindanao purchased from Mr. Clagg, mostly Diptera, Hymenoptera, Hemiptera, Neuroptera and spiders; about two thousand miscellaneous insects collected in Guatemala by Dr. Bequaert, over one thousand Hymenoptera and Diptera, collected in Texas, Arizona, and California by Dr. Bequaert; over two thousand specimens from Soledad near Cienfuegos, Cuba, collected by the curator; about one thousand spiders from the same locality taken by L. Worley. Mr. Worley has also given his large collection of spiders from Washington State. Miscellaneous Diptera from Canada and China through the kindness of Dr. Crampton.

NATHAN BANKS.

*Bernice P. Bishop Museum*, Honolulu, Hawaii: Recent large accessions of insects, received by this Museum, are: Kellers collection from Samoa, the Giffard collection of Hawaiian Cixiidae (Homoptera), and numerous Hawaiian Hymenoptera and Coleoptera, all from the late Walter M. Giffard. R. C. L. Perkins collection of Hawaiian insects, which are a part of the very extensive collection upon which the Fauna Hawaiiensis was based. (All but the Coleoptera received to date.) These are the gift of Dr. Perkins. D. T. Fullaway collection from Samoa. Numerous specimens from the Hawaiian Islands, especially from Waialeale, Kauai, Molokai; West Naui Mountains, and various parts of Melanesia, especially the Solomon Islands. The present entomological work of the Museum is being done through the Pacific Entomological Survey, in co-operation with the local Sugar and Pineapple Experiment Stations. Extensive collections have been made in the Marquesas and Society Islands, and are now being worked up by a number of specialists.

E. H. BRYAN, JR.

*University of Missouri:* During the past year the entire collection of identified insects has been rearranged, following the arrangement of recognized authorities. The Coleoptera have been relabelled in accordance with Leng's Catalogue. The Coleoptera collection has been added to by exchanges with South Dakota State College, Brookings; Mr. Arthur T. McClay, University of California, Berkeley; Mr. Bernard Benesh, North Chicago, Ill.; Mr. Paul N. Musgrave, Fairmont, West Virginia; Mr. C. A. Thomas, Kennett Square, Pennsylvania. These additions have been principally in the families Chrysomelidae and Carabidae. The University collection of labelled specimens consist of the following: Coleoptera, 10,000 named, 1,000 unnamed; Lepidoptera, 3,500 named; Homoptera, 3,000 named, 500 unnamed; Diptera, 2,500 named, 600 unnamed; Hymenoptera, 1,000 named, 500 unnamed; Orthoptera, 600 named; Hemiptera, 600 named, 150 unnamed; other orders, 500; total, 21,700 named, 2,750 unnamed. The working material for students approximately equals the labelled collection.

L. HASEMAN.

*Boston Society of Natural History:* The Society through the co-operation of Mr. Frank M. Jones and others is making an intensive study of the insect fauna of Martha's Vineyard, Massachusetts. At the present time about 1,600 species have been determined, among which are many austral species not previously found in New England. Two seasons more will probably be spent on this work.

CHAS. W. JOHNSON.

*The Francis Huntington Snow Entomological Museum, University of Kansas:* Since our last report in 1927 the collections have been greatly enhanced by the addition of much new material and by classification studies and the rearrangement of the collections in several orders.

Each summer a collecting party under the direction of Dr. R. H. Beamer has been in the field.

In addition to the 125,000 insects taken on various expeditions, by the University of Kansas Entomological collecting parties, Hungerford has added many insects each summer from Michigan, and various former students have made donations. Many exotic insects, mostly Hemiptera and Homoptera, have been added in recent years. In addition to the study and rearrangement of the collection in various genera of the Hemiptera and Homoptera, there have been two most noteworthy contributions:

Mr. Warwick Benedict not only has given his splendid collection of Coleoptera to the University, but has made substantial progress toward rearranging, repinning and relabeling the Francis Huntington Snow collection of Coleoptera and in incorporating his own collection, thus greatly increasing an already valuable collection. So far he has contributed 6,443 specimens, representing 702 species, including 4 types and 41 paratypes. Through exchange and determination Mr. Benedict has further strengthened the Coleoptera collection by 1,256 specimens, including 321 species and 23 paratype specimens. Thus, through Mr. Benedict's generosity and labors 1,023 species of Coleoptera new to the University of Kansas collections have been added.

The Orthoptera collection is now in splendid condition, thanks to the extended study made by Mr. Morgan Hebard. (See Proc. Acad. Nat. Sci. Phila., Vol. XXXIII, 1931, p. 119–227.)

The following summary, compared with the figures of 1927, will show the increase since that time:

| Order | Total No. Species | Total No. Specimens | Type Species | Type Specimens | Undet. Specimens |
|---|---|---|---|---|---|
| Hemiptera | 1,372 | 55,701 | 251 | 4,261 | 55,285 |
| Homoptera | 1,339 | 54,325 | 300 | 4,503 | 67,620 |
| Orthoptera | 656 | 15,534 | 27 | 117 | 600 |
| Diptera | 3,156 | 8,051 | 742 | 2,723 | 45,909 |
| Hymenoptera | 2,388 | 9,652 | 325 | 525 | 38,652 |
| Lepidoptera | 4,737 | 13,914 | 100 | 196 | 4,685 |
| Coleoptera | 9,010 | 44,000 | 90 | 298 | 62,400 |
| Neuroptera | 350 | 1,500 | 5 | 8 | 1,078 |
| Miscellaneous Specimens | | | | | 25,000 |
| Totals | 23,008 | 202,677 | 1,840 | 12,631 | 301,229 |

The increase in the types is due largely to publications by staff members and their graduate students.

H. B. Hungerford.

*Committee:* Herbert Osborn, *Chairman*,
J. G. Needham, Nathan Banks,
C. W. Johnson, E. C. Van Dyke.

HAROLD MORRISON, who was appointed by PRESIDENT FOLSOM to represent our Society at a meeting of the Union of American Biological Societies held in Washington, March 7, reported by letter. The meeting dealt with Biological Abstracts and the importance of individual and organization support. The report was accepted with thanks.

J. C. BRADLEY reported for O. A. JOHANNSEN, Chairman of the Committee to Arrange Itineraries to the International Entomological Congress to be held in Paris, July, 1932. The following statement from DR. JOHANNSEN was read: "The number of favorable answers received in response to the circulars and questionnaires sent out last summer, warrants a continuance of plans for providing transportation to Europe in two groups, one sailing from New York on June 11th, returning to New York, September 25th; the other sailing July 1st, and returning September 5th. Provisions are also made for those going directly to Paris without stopping at intermediate points.

"Through the kind co-operation of our colleague, DR. J. C. BRADLEY, who expects to spend the summer in Europe, the committee has gone farther than originally contemplated in arranging groups for visiting centers of entomological points of interest in other parts of Europe for those who have expressed a wish to travel together. A list of steamers on which the groups may find it convenient to travel, as well as the places of interest, entomological and otherwise, are given on the mimeographed sheets accompanying this report."

E. P. FELT was appointed by PRESIDENT FOLSOM to represent the Society as a Councillor to the A. A. A. S. since our duly elected councillors were not present. No report was received.

HERBERT OSBORN and D. M. DELONG were appointed as alternates to represent the Society at the meeting of the Union of Biological Societies. No report was received.

J. C. BRADLEY presented the following statement: "In view of the fact that the international congresses of zoology are an inadequate source of ascertaining the world wide opinion of zoologists in regard to nomenclatorial and other matters affecting their science, be it *Resolved*, That a committee of this Society be appointed to consider the advisability of taking steps toward the formation of a permanent international organization of zoologists, the business of which should be transacted by ballot of the members through the mails, and not at international meetings, and with a further view of such organization taking over from the International Congresses the responsibility for maintaining the International Commission on Zoological Nomenclature, leaving to the Congresses unlimited opportunity of discussion, but not of legislation.

"That such Committee be empowered to co-operate with committees of similar purport of other zoological societies, or to invite the co-operation of such societies, and to take such steps as may seem expedient toward international organization."

On motion the recommendation was approved and the President instructed to appoint a committee to investigate the proposal.

On motion the President was instructed to appoint a Membership Committee.

F. E. LUTZ, our Society representative of the Division of Biology and Agriculture of the National Research Council and G. C. CRAMPTON, Chairman of the Committee on Anatomical Terminology, were not present to give reports.

Following the transaction of business, the meeting adjourned.

The following interesting and instructive exhibits were presented during the meetings:

1. Photographs of Chironomid Egg Masses. HAZEL E. BRANCH, University of Wichita.
2. Coleoptera of the Alabama and Mississippi Gulf Coast Strip. H. P. LODING, Mobile, Alabama, and HENRY DIETRICH, Lucedale, Miss.
3. Salt Marsh Sand-Flies (Culicoides). W. E. DOVE, U. S. Bureau of Entomology.
4. Prospectus of a Loose-Leaf Laboratory and Field Manual of Economic Entomology. JOHN R. EYER, New Mexico A. & M. College.
5. Feeding Punctures of Chinch Bugs in Sorghums. REGINALD H. PAINTER, Kansas State Agricultural College.
6. First showing of book on the classification of insects. C. T. BRUES and A. L. MELANDER.

Wednesday evening, December 30, the members met with the American Association of Economic Entomologists at the La Louisiane for the Annual Entomologists' Dinner, with HERBERT OSBORN as guest of honor.

Respectfully submitted,

J. J. DAVIS, *Secretary.*

# BOOK NOTICES.

LA PARTHENOGENESE, by A. VANDEL, (Encyclopedie Scientifique, Vol. 7), pp. I–XIX–412. G. Doin & Cie, Paris.

This volume is a very complete review of the facts and literature on parthenogenesis in insects with a chapter on that in other animals and one on parthenogenesis in plants. Chapter I is historical and introductory; II covers definitions and forms; III, arrenotokous parthenogenesis; IV, cyclic parthenogenesis; V, paedogenesis, and VI, accidental parthenogenesis. Chapter IX is on the cytology of parthenogenesis, XI on experimental parthenogenesis and XII on parthenogenesis and sex. The bibliography covers pages 329 to 383 and is arranged to follow the subject matter of the chapters.—C. H. K.

MEDICAL ENTOMOLOGY, by WILLIAM A. RILEY AND OSKAR A. JOHANNSEN, pp. 476 with 184 text figures, 1932. McGraw-Hill Book Company, Inc., New York and London.

This is a revision and enlargement of the work issued by the authors in 1915. While that treated the organisms considered under three general headings, the present volume takes them up in their systematic order, beginning with Crustacea and ending with Insecta Hymenoptera. The book opens with a short but very interesting chapter on the early history of the subject which is followed by a short chapter on how these organisms affect man and his domestic animals. Chapters III to XXIV comprise the body of the work in which the material is arranged systematically. This is a text book with the material very highly selected, well organized and the controversial matters briefly but clearly and interestingly stated. The bibliography is limited to the more important items so that it covers only thirty pages. The work is so well written that it makes interesting reading for any biologist or medical man.—C. H. K.

VERGLEICHENDE ANATOMIE DES NERVENSYSTEMS DER WIRBELLOSEN TIERE, by BERTIL HANSTROM, pp. I-XI-628 with 650 text figures, 1928. Published by Julius Springer, Berlin.

We wish to call the attention of those entomologists interested in insect behavior and the structure of the insect nervous system to this remarkable work on the comparative anatomy of the invertebrate nervous system. The one hundred and eighty pages of Chapter XXIII are devoted to the minute anatomy of the insect nervous system as worked out by such students as Cajal, Zawarzin and others. The work is beautifully illustrated with many diagrams from Golgi and similar preparations, is fully documented and is written from the point of view of function of the parts. Because of postal rules we cannot state the price, but we caution those deciding to purchase the work to first enquire concerning the same.—C. H. K.

CLASSIFICATION OF INSECTS, A Key to the Known Families of Insects and Other Terrestrial Arthropods, by CHARLES T. BRUES and A. L. MELANDER, pp. 1–672, 1121 text figures. Bulletin of the Museum of Comparative Zoology at Harvard College, Vol. LXXIII.

The first sixteen pages are introductory. Then follow Part I, Insecta, pages 17–528; Part II, Other Terrestrial Arthropoda, pages 529–604; Glossary, pages 605–616 and Index to Genera and Higher Groups, pages 617–672. This book is an outgrowth of the earlier volume published by the authors in 1915 which was limited to the families of North American insects. "The new volume has been

entirely rewritten to include the families of the entire world, and in many cases the subfamilies of more important groups. A selected list of literature has been added, and so far as possible, keys for the identification of immature stages." To this body of the work have been added keys to the other groups of Terrestrial Arthropoda. As indicated by the title, this is a book of keys. It will be very useful to students interested in the broader aspects of the classification of insects. It makes available a much needed key to the Hymenoptera. The writer can speak critically only of the key to the Odonata. This follows the latest work of Tillyard and others, but still includes the Dicterias-Heliocharis series of South America in the Epallagidae. The larvae and male genitalia indicate that these are more closely related to the primitive Agriidae. Few entomologists have realized the great difficulties involved in work of this kind in keying the primitive and intergrading series of Australian and South American insects into the more highly differentiated groups of Eurasia and North America in which the key characters are more easily defined. It is an excellent and useful piece of work.—C. H. K.

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FUNDAMENTALS OF INSECT LIFE, by C. L. METCALF and W. P. FLINT, pp. I-XI-581, 315 text figures. McGraw-Hill Book Company, Inc., New York and London.

As stated in the introduction this volume places emphasis on the biological aspects of entomology rather than on the economic or agricultural. The first chapter, "Insects as Enemies of Man," indicates that it is from the point of view and experiences of an economic entomologist. This crossing of two interests weaves the whole together in such a way that the student gets a view of the whole field of entomology with the economic limited to two chapters on the general methods of control and two chapters covering the relation of insects to man. Chapter headings (abbreviated) are as follows: I, Insects as enemies of man; II, Value of insects to man; III, External morphology; IV, Internal anatomy and physiology; V, Mouth parts; VI, Development and metamorphosis; VII, Place of insects among animals; VIII, Orders and families; IX, Control; X, Apparatus for applying insecticides; XI, The living environment of insects; XII, The Physico-chemical environment; and XII, Insect behavior. This is a comprehensive and excellent general text book for classes in which it is not desirable to feature economic entomology. It will be good for collateral reading in courses on systematic entomology. The illustrations are mostly old friends but are well chosen. Altogether it is a step forward in text book writing.—C. H. K.

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AN ILLUSTRATED SYNOPSIS OF THE PRINCIPAL LARVAL FORMS OF THE ORDER COLEOPTERA, by ADAM G. BOVING and F. C. CRAIGHEAD, pp. i-viii-86, 125 plates, Brooklyn Entomological Society, Brooklyn, New York.

This volume is the product of over fifteen years of continuous research by the senior author and several years of research by the junior author. The one hundred and twenty-five plates carry from ten to twenty-five figures each, practically all of which are original illustrations of the larvae of the Coleoptera. Following an introductory three pages on the relationships of the Suborders to each other is a sixty-page key for the identification of larvae to families and subfamilies. The keys are very full, carrying the characterizations of the various larval forms in much detail. Numerous footnotes discuss and amplify the characterizations in the keys. Following this is a list of the six previous works covering the larvae of the Coleoptera as a whole, then a Conspectus of the species treated which gives page and plate references and finally six pages of explanations of the abbreviations used on the figures. Thus the text is extremely condensed while the beautiful plates carry the wealth of facts and the keys sort them out and make them available. Because of the great amount of exacting research, the completeness of illustration and the breadth of the work this volume is one of the outstanding works in systematic entomology. Words and space fail us in expressing our appreciation of it.—C. H. K.